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CHEMICAL LASER SYSTEMS:
AN ENGINEERING APPROACH
Volume [redacted] I. CHEMICAL LASER ANALYSIS PROGRAM,

U.S. ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND

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The Chemical Laser Analysis Program presented in this report is a computer program for the rapid, parametric evaluation of high energy, chemical laser systems including the combustion chemistry, laser device gas dynamics, various diffuser-ejector pressure recovery subsystems, and system volume/mass estimates. The program does not calculate specific laser power but relies on experimental data for scaling information. The FORTRAN EXTENDED computer program listing, as well as detailed information on program development, organization, and operating procedure are given along with a complete program

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abstract (continued)

nomenclature and two sample cases.

CONTENTS

ACKNOWLEDGMENT

The Chemical Laser Analysis Program represents the culmination of 10 years experience in the chemical laser field by personnel at the US Army Missile Research and Development Command. Special credit goes to Dr. B. J. Walker and Dr. R. L. Oglukian who formulated the original code, especially the SYSTEM CALCULATION SECTION, and to Dr. A. L. Addy who, with the author, formulated much of the PRESSURE RECOVERY SECTION. Among those deserving of recognition are Dr. G. F. Morr and Messrs. R. D. Massey, C. L. Adams, and S. L. Pruett who worked on earlier versions of the program.

I. INTRODUCTION

A chemical laser weapons system is a complex device that requires an amalgamation of various scientific disciplines. These include chemical kinetics, optics, fluid dynamics, quantum mechanics, etc. The interaction of these various disciplines are, at best, complicated. However, it remains that if a high energy chemical laser weapons system is to be built successfully, it is necessary that this interaction be understood.

A considerable effort has been made to analyze an entire chemical laser system from an engineering point of view, to describe such as system by a set of governing equations, and finally, to simulate a chemical laser system through solution of the governing equations utilizing the Chemical Laser Analysis Program (CLAP).

The CLAP program was developed primarily from a fluid dynamics viewpoint which essentially means that specific laser power is purposely not calculated, but is obtained from experimental data. This probably enhances the credibility of the results obtained by the use of the program since the calculation of specific power would be closely tied to all the fluid dynamical and reaction kinetics calculation techniques and subject to those uncertainties plus the uncertainties inherent in the specific power calculation itself. CLAP does, however, consider all other aspects of a chemical laser system, including the combustion chemistry, gas dynamics, and mass/volume estimates.

CLAP was designed specifically as a tool for the rapid parametric evaluation of proposed chemical laser systems. Pursuant to this goal, the program was written:

a) By using simple methods of analysis, in particular, the one-dimensional methods of gas dynamics wherever possible.

b) For minimum user input requirements with over 22 user controlled options for maximum flexibility.

c) For use in an interactive mode for minimum turn-around time and maximum user convenience.

d) In a stacked or series configuration to maximize calculational efficiency and minimize user costs.

Although written to reflect the state-of-the-art in chemical laser technology, the authors realize that most users will wish to modify the code with minimum effort for their own unique studies. To this end the program was written:

a) With a consistent notation scheme throughout and a single system of units, the SI (metric) system.

b) With a considerable amount of internal documentation such that most any user with a basic knowledge of chemical laser systems can comprehend the background theory and logic.

The CLAP program listed in Appendices A through E was written in FORTRAN EXTENDED for use on Control Data Corporation computers having an INTERCOM Version 4 interactive capability, but is readily adapted to run on other machines in either an interactive or batch mode.

II. PROGRAM ORGANIZATION

A. General

CLAP as listed in Appendices A through E is written in five overlays consisting of the root overlay, MAIN, and four primary overlays, COMBUSTION CHEMISTRY SECTION (CCS), LASER DEVICE SECTION (LDS), PRESSURE RECOVERY SECTION (PRS), and SYSTEM CALCULATION SECTION (SCS). Calculations are performed sequentially through the primary overlays in the following order: (1) CCS, (2) LDS, (3) PRS, and (4) SCS. However, it should be noted that the pressure recovery and system calculation sections are optional. Calculations in a given primary overlay are executed only if the input data are changed for that or a previous overlay.

Block common statements are used to store the output from each primary overlay in the root overlay. In addition, these block common statements serve to pass information between primary overlays through the root overlay. Variables are brought into a given program or subroutine through COMMON or CALL statements only if actually required. A block common-program/subroutine cross reference is included in Table 1.

Each primary overlay has its own input and output subroutines, INCCS, DUTCCS, etc. All input is either by NAMELIST or alphanumeric symbols (e. g., "YES" and "NO"). Furthermore, each input subroutine contains default values for the input variables and the logic to store the latest input data on a separate file, TAPE1, TAPE2, etc., for easy restarts. A list of these and other TAPE/unit definitions are given in Table 2.

All calculations, with the exception of one subroutine, DUTENG, are performed in either dimensionless or the SI system of units following Mechtly [1].

A nomenclature list for each program and subroutine is given in Appendix F. The nomenclature for each primary overlay follows a general scheme whenever possible with the exceptions defined separately.

As an aid to the user, the CLAP code is liberally interspersed with comment statements to identify the purpose of the program or subroutine,

Program/ Subroutine	CCS1	CCS2	CCS3	CCS4	CCS5	CCS6	CCS7	CCS8	CCS9	CCS10	CCS11	CCS12	CCS1
MAIN	X								X	X			X
OUTENG		X	X	X	X	X	X	X			X	X	
CCS	X	X	X	X	X	X	X	X	X	X	X	X	X
INCCS	X	X	X		X								
OUTCCS		X	X	X	X	X	X	X				X	
LDS	X		X				X				X	X	
INLDS													
LPNCS			X	X									X
LSNCS1			X					X					
LSNCS2			X					X					
OUTLDS											X		
PRS													
INPRS													
OUTPRS													
SCS			X	X	X		X		X	X	X		
INSCS			X		X					X			
OUTSCS													
VMAW													
VMCS													
VMC2H4													
VMD2													
VMF2													
VMHE													
VMH2													
VMIRFNA													
VMMMH													
VMNF3													
VMN2													
VMN2H4													

TABLE 1. BLOCK COMMON-PROGRAM/S

															BLOCK COM
1	CCS12	CCS13	CCS14	CCS15	CCS16	LDS1	LDS2	LDS3	LDS4	LDS5	LDS6	MAIN1	MAIN2	MAIN3	MAIN
		X	X	X	X	X						X	X	X	X
	X						X	X	X	X	X		X		
	X	X	X	X	X										
														X	
	X														
	X					X	X	X	X	X	X	X	X		
						X	X			X					X
		X	X	X											
			X	X	X										
			X	X	X										
							X	X	X	X	X		X		
						X			X			X			
									X						
									X						
				X						X	X				
												X			

M-PROGRAM/SUBROUTINE CROSS REFERENCE

BLOCK COMMON

MAIN3	MAIN4	MAIN5	MAIN6	PRS1	PRS2	PRS3	PRS4	PRS5	PRS6	SCS1	SCS2	SCS3	SCS4	SCS5	SCS6
X	X	X	X	X									X		
					X	X	X	X	X	X	X	X		X	
X															
	X														
				X	X	X	X	X	X						
		X		X		X		X	X						
					X	X	X	X	X						
							X	X	X	X	X	X	X	X	
			X					X		X	X		X	X	X
								X			X	X		X	
													X	X	X
													X	X	
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													X	X	
													X	X	
													X	X	
													X	X	

3

SCS5	SCS6	SCS7	SCS8	SCS9	SCS10	SCS11	SCS12	SCS13	SCS14	SCS15	SCS16	SCS17
X												
X												
X	X	X	X	X	X	X	X	X	X	X	X	X
X												
X	X											
X		X										
X			X									
X				X								
X					X							
X						X						
X							X					
X								X				
X									X			
X										X		
X											X	
X												X

TABLE 2. TAPE/UNIT DEFINITIONS

TAPE or Unit No.	Purpose
1	Binary input/output file either read or written from subroutine INCCS to store the latest input data for CCS.
2	Binary input/output file either read or written from subroutine INLDS to store the latest input data for LDS.
3	Binary input/output file either read or written from subroutine INPRS to store the latest input data for PRS.
4	Binary input/output file either read or written from subroutine INSCS to store the latest input data for SCS.
5	Connected file for the interactive output of information to the CLAP program from a terminal keyboard.
6	Connected file for the interactive input of information from the CLAP program to a CRT display.
20	Formatted output file written from subroutines DUTCCS, DUTLDS, DUTPRS, and DUTSCS to print the results of the CLAP program in SI units on 132 character line printers.
30	Formatted output file written from subroutine DUTENG to print the results of the CLAP program in mixed engineering units on 132 character line printers.

to define the input/output variables, and to describe each step of the calculations. Furthermore, a system of failure flags and error messages have been set up to assist in the location of failures.

B. MAIN

The root overlay, MAIN, calls the primary overlays in sequence and stores the output of the primary overlays.

Subroutine DUTENG contained in the MAIN overlay converts the output of the CLAP program to a mixed system of engineering units and is the only subroutine which does not use the SI system. The converted variables are stored in separate core locations to eliminate the need of converting back to SI units, thus avoiding any mixed unit errors.

C. COMBUSTION CHEMISTRY SECTION (CCS)

The primary overlay CCS performs all the combustion chemistry calculations for the laser primary combustor and laser cavity for either DF or HF laser chemistry. Any primary combustor fuel of the form $C_{N1}H_{N2}$ or $C_{N1}D_{N2}$ and any primary combustor oxidizer of the form $N_{N3}F_{N4}$ may be used. Both helium and nitrogen are allowed as diluents; however, the cavity mirror purge gas is assumed to be nitrogen.

Because of differences in definitions existant in the laser community, some of the variables listed in the nomenclature for CCS require further definition. These are:

ALPHA = Fluorine dissociation fraction

$$\alpha = \frac{\text{moles F}}{\text{moles F} + 2\ \text{moles}\ F_2}$$

PSIC = Molar combustor diluent ratio

$$\psi_C = \frac{\text{moles diluent} + \text{moles other}}{\text{moles}\ F_2 + 1/2\ \text{mole F}}$$

PSIL = Molar cavity diluent ratio

$$\psi_L = \frac{\text{moles diluent} + \text{moles other}}{\text{moles}\ F_2 + 1/2\ \text{mole F}}$$

PSILTRW = Molar cavity diluent ratio (TRW definition)

$$\psi_{L\text{-}TRW} = \frac{\text{moles diluent}}{\text{moles}\ F_2 + 1/2\ \text{mole F}}$$

OMEGA = Total laser molar diluent ratio

$$\Omega = \psi_C + \psi_L$$

OMEGTRW = Total laser molar diluent ratio (TRW definition)

$\psi_{TRW} = \psi_C + \psi_{I-TRW}$

RC = Molar combustor mixture ratio

$$R_C = \frac{\text{moles oxidizer}}{\text{moles of fuel required to react stoichiometrically with all the oxidizer}}$$

RL = Molar cavity mixture ratio

$$R_L = \frac{\text{moles of cavity fuel}}{\text{moles } F_2 + 1/2 \text{ mole } F}$$

RLF = Total laser cavity mixture ratio

$$R_{LF} = \frac{\text{moles of cavity fuel} + \text{moles of cavity diluent}}{\text{moles } F_2 + 1/2 \text{ mole } F}$$

D. LASER DEVICE SECTION (LDS)

The primary overlay LDS performs the gas dynamic calculations for the laser device including the primary and secondary nozzles and the laser cavity. All calculations are based on 1 kmole/s of laser primary nozzle flow; hence, the units on flow area, for example, are (s-m^2)/kmole.

No attempt was made to predict heat loss in the laser nozzles, nor was any rigorous boundary layer analysis applied to a given nozzle profile. Instead, the nozzle stagnation temperature is either estimated or taken from experimental data and the nozzle boundary layer thickness is computed using a simple correlation equation from the throat to exit plane. All the nozzle flow is assumed to pass through the core or "effective" flow area as shown in Figure 1. Finally, a simple correction is applied, namely adjusting the number of nozzles for 1 kmole/s of primary flow, to correct for the change in specific heat ratio due to temperature change from the nozzle throat to exit.

Totally viscous, subsonic nozzle flow, i.e. all boundary layer flow in converging-diverging nozzles, is not allowed and has been the most common failure encountered with the CLAP program in subroutines LPNCS and LSNCS1. Constant-area, sonic secondary laser nozzles are treated separately as Fanno flow devices in subroutine LSNCS2.

Two nozzle calculational procedures are followed. For the primary nozzles, either the nozzle stagnation temperature is specified and the stagnation pressure is computed or vice versa. For the laser secondary nozzles, however, the stagnation pressure is always computed for a given

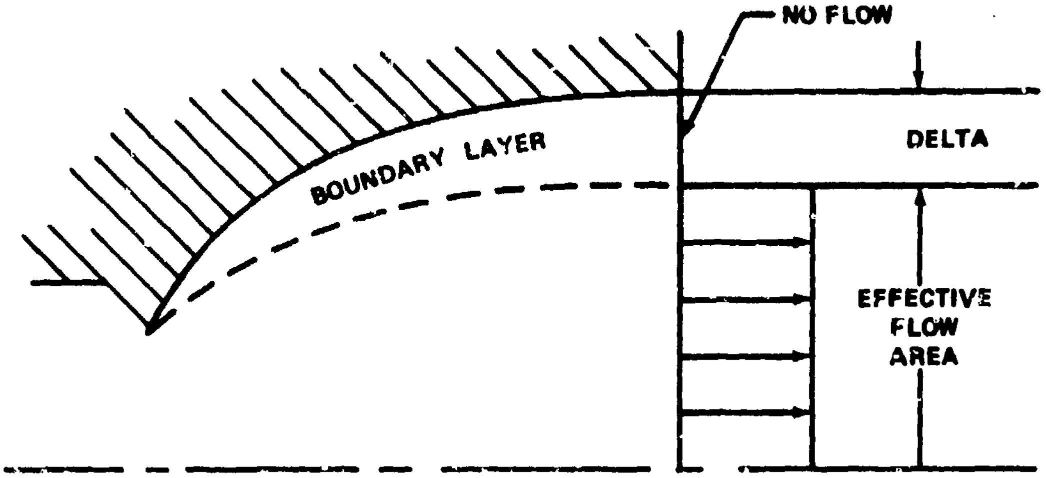

Figure 1. Laser nozzle boundary layer.

stagnation temperature. When both the primary nozzle stagnation temperature and pressure are known, as when scaling up from an experimental device, the usual procedure is to match both experimental values by adjusting the primary nozzle throat diameter, D1S, which will ordinarily vary from the design value due to thermal expansion or throat errosion.

The complex mixing and reacting cavity flow is broken down into three simple processes separated by station numbers as designated in the nomenclature of Appendix F and illustrated in Figure 2. First, the effective primary and secondary nozzle flows are assumed to mix at constant-area to a uniform stream and then expand isentropically to the full cavity flow area at the nozzle face. Next, the mass addition, chemical reaction, and accompanying heat release calculations are carried out step-wise to the cavity exit similar to the cavity analysis given by Addy and Mikkelsen [2] and outlined in Shapiro [3]. Included in the cavity analysis is an empirical flow separation test after Zukoski [4] which has proven to be an important criterion in laser scale-up design operations, especially for devices with low bank relief nozzles [5].

The specific heat at constant pressure and absolute viscosity data included in subroutines CPCALC and VISC were taken largely from two sources, the JANAF [6] and NASA [7] tables, respectively. Subroutine VISC computes the viscosity of gas mixtures using the semi-empirical formula of Wilke [8].

E. PRESSURE RECOVERY SECTION (PRS)

The primary overlay PRS performs the gas dynamic calculations for the laser pressure recovery subsystem. Again, as in LDS, all calculations are based on 1 kmole/s of laser primary nozzle flow. Most of this section is described in and taken from Mikkelsen, Sandberg, and Addy [2, 9, 10].

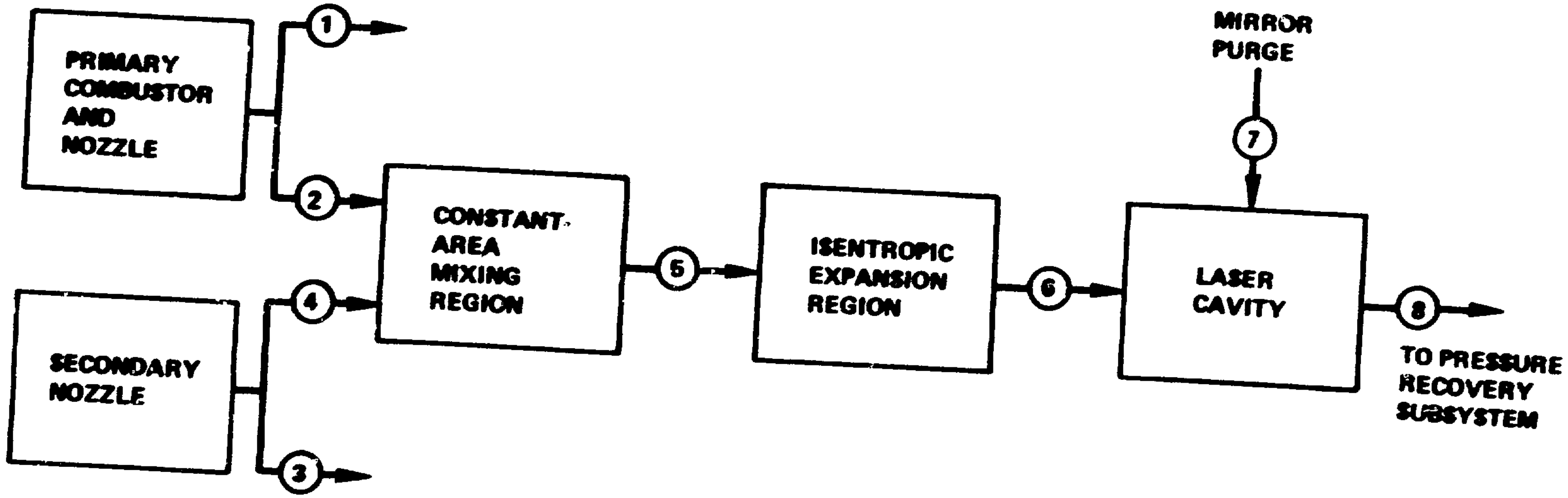

Figure 2. Laser device subsystem schematic.

The PRS overlay calculations are optional; however, the user may select from three pressure recovery subsystems including (1) a supersonic-subsonic diffuser; (2) a supersonic-subsonic diffuser and constant-area, subsonic-supersonic ejector; and (3) a constant-area, supersonic-supersonic ejector. The constant-area, supersonic-supersonic ejector analysis differs only slightly from that of Mikkelsen, et al., in that a Zukoski [4] type of separation criteria has been added to the options for limiting ejector operation. A flow schematic for the pressure recovery options with station numbers corresponding to the nomenclature of Appendix F is given in Figure 3.

To give the best ejector system possible as well as minimize user inputs, each of the ejector systems are optimized to give the minimum driver-to-driven stream mass flow ratio for a specified driver stagnation pressure. Care, however, is required since impossible pressure recovery requirements, either too high or too low, have been the most common cause of failures in the optimization routines. Since the ejector optimization routines are somewhat more time consuming, usual practice with proposed chemical laser designs is to select the supersonic-subsonic diffuser option and to vary the laser device flow conditions until a desired pressure recovery at the subsonic diffuser exit is achieved.

F. SYSTEM CALCULATION SECTION (SCS)

The primary overlay SCS, using output from the other primary overlays and system scale-up information, estimates the mass and volume of a chemical laser system including reactants, storage tanks, lines, supports, regulators, optics, etc. Unfortunately, the systems analysis leading to the computer algorithms is too extensive to include in this volume but will be published later. This is particularly unfortunate since the analysis is not readily apparent from the computer code, especially for the tank factor subroutines. The majority of the work is original with much of the data complied from Department of Defense technology programs.

Since specific power calculations have been avoided in CLAP, the hypothetical laser system is scaled to size by specifying the mass flow rate of free fluorine and the laser run time. The principal dimensions are then readily determined since the mole fraction and mole flux of free fluorine are known from the CCS and the flow area in LDS and PRS were based on 1 kmole/s of laser primary flow.

An example of a single-ejector, a single-bank chemical laser configuration is shown in Figure 4, with the prinicpal dimensions of the transition piece and subsonic-supersonic ejector given in Figures 5 and 6. The subsonic-supersonic ejector is of the variable-area type which should just meet the theoretical constant-area ejector performance calculated in PRS. A supersonic-supersonic ejector option (Figure 7) is included in SCS; however, this particular configuration is an untested design

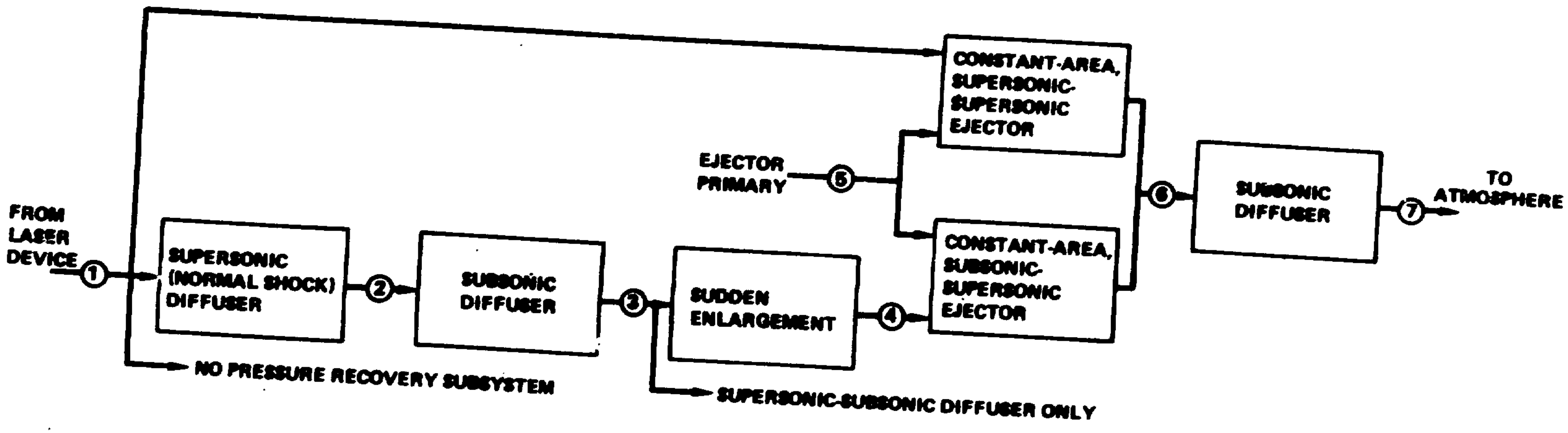

Figure 3. Pressure recovery subsystem schematic.

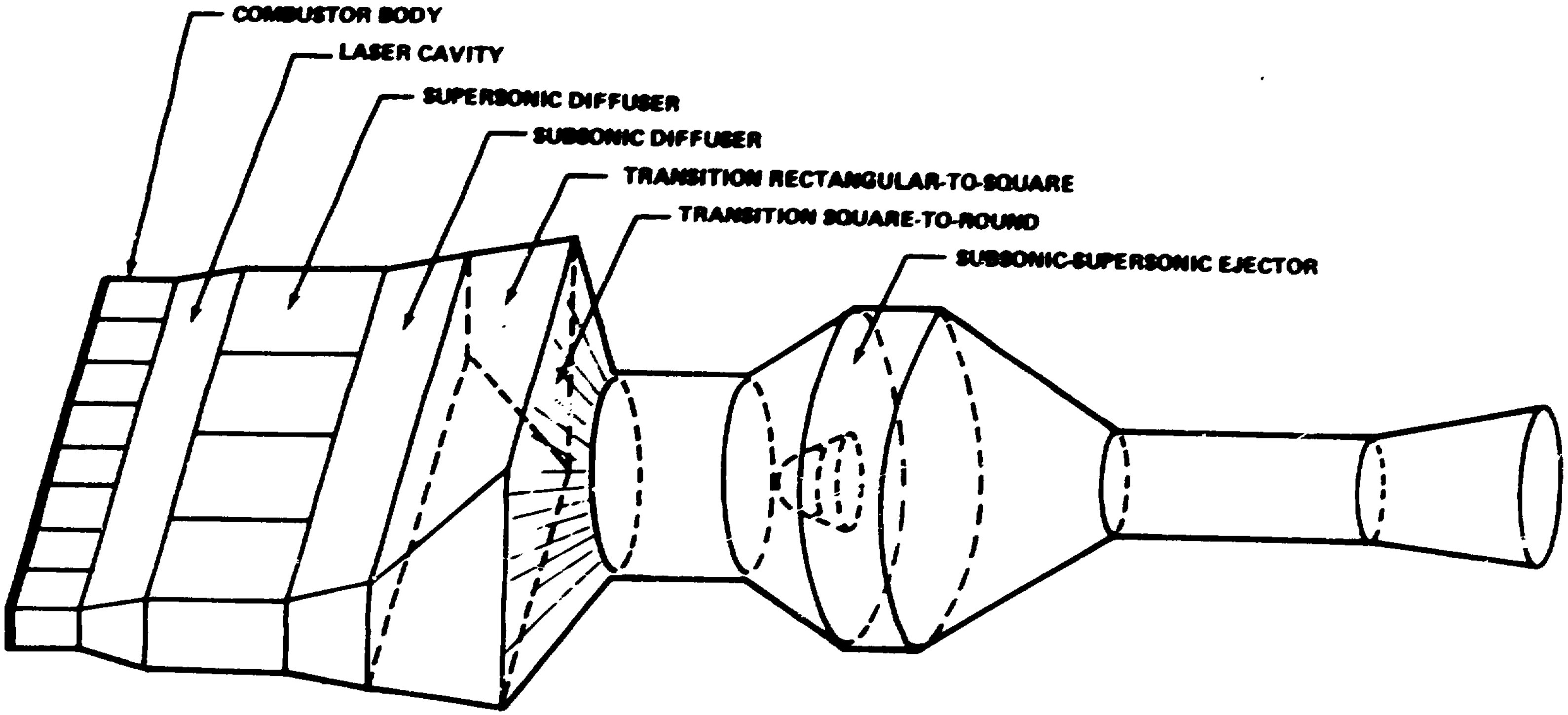

Figure 4. Single-ejector, single-bank laser configuration.

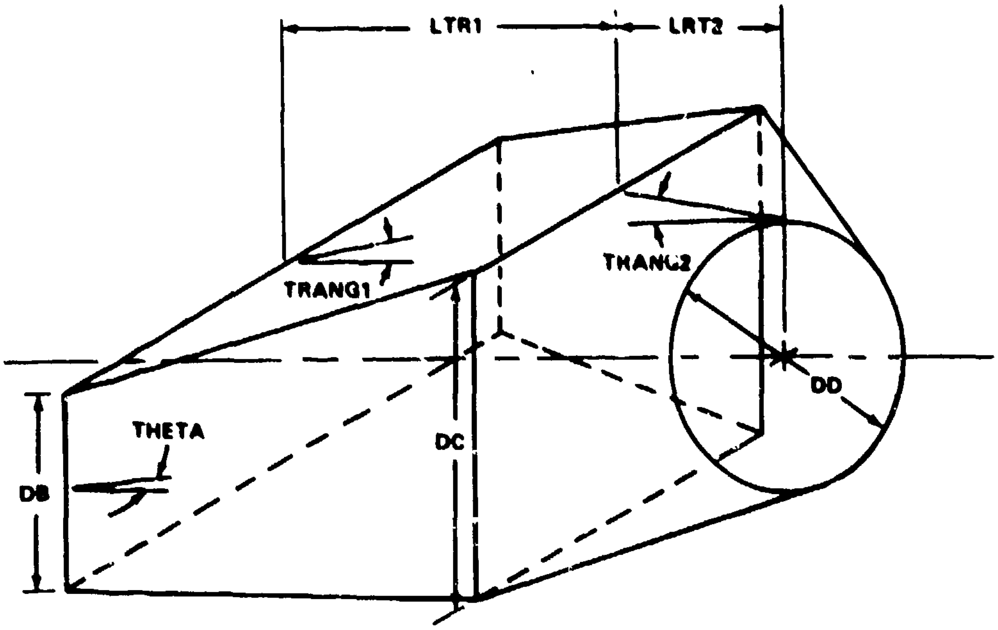

Figure 5. Subsonic-supersonic ejector transition piece.

and strictly proposed for comparison with subsonic-supersonic ejector systems. More than one laser bank and more than one ejector per bank may be specified, but the total number of ejectors per bank is limited such that the height-to-width ratio at the transition section entrance is no greater than unity.

Storage tank volume/mass subroutines are included in SCS for laser fuels C_2H_4, H_2, and D_2; for laser oxidizers F_2 and NF_3; and for laser diluents He and H_2. Helium is stored as a mixture with the fluorine oxidizer when used only as a primary diluent. N_2H_4 is included as a monopropellant ejector driver fluid and IRFNA/MMH for a biopropellant system. Similar volume/mass subroutines were written for the laser cooling system and nitrogen-driven aero-window.

The laser reactants may be stored in a number of ways given in the listing for each volume/mass subroutine and summarized in the reactant storage mode nomenclature of Appendix F. Cryogenic storage options utilizing a triple vacuum jacket and liquid nitrogen boil-off for thermal protection are included for most of the reactants. Gases are always delivered with a blow-down system whereas liquids are delivered via pressurized gas, pump feed, or heater pressurization systems as illustrated in Figures 8, 9, and 10. Water is delivered to the cooling system by the same schemes used for other liquid reactants with the addition of a radiator-fan-pump recirculation system shown schematically in Figure 11.

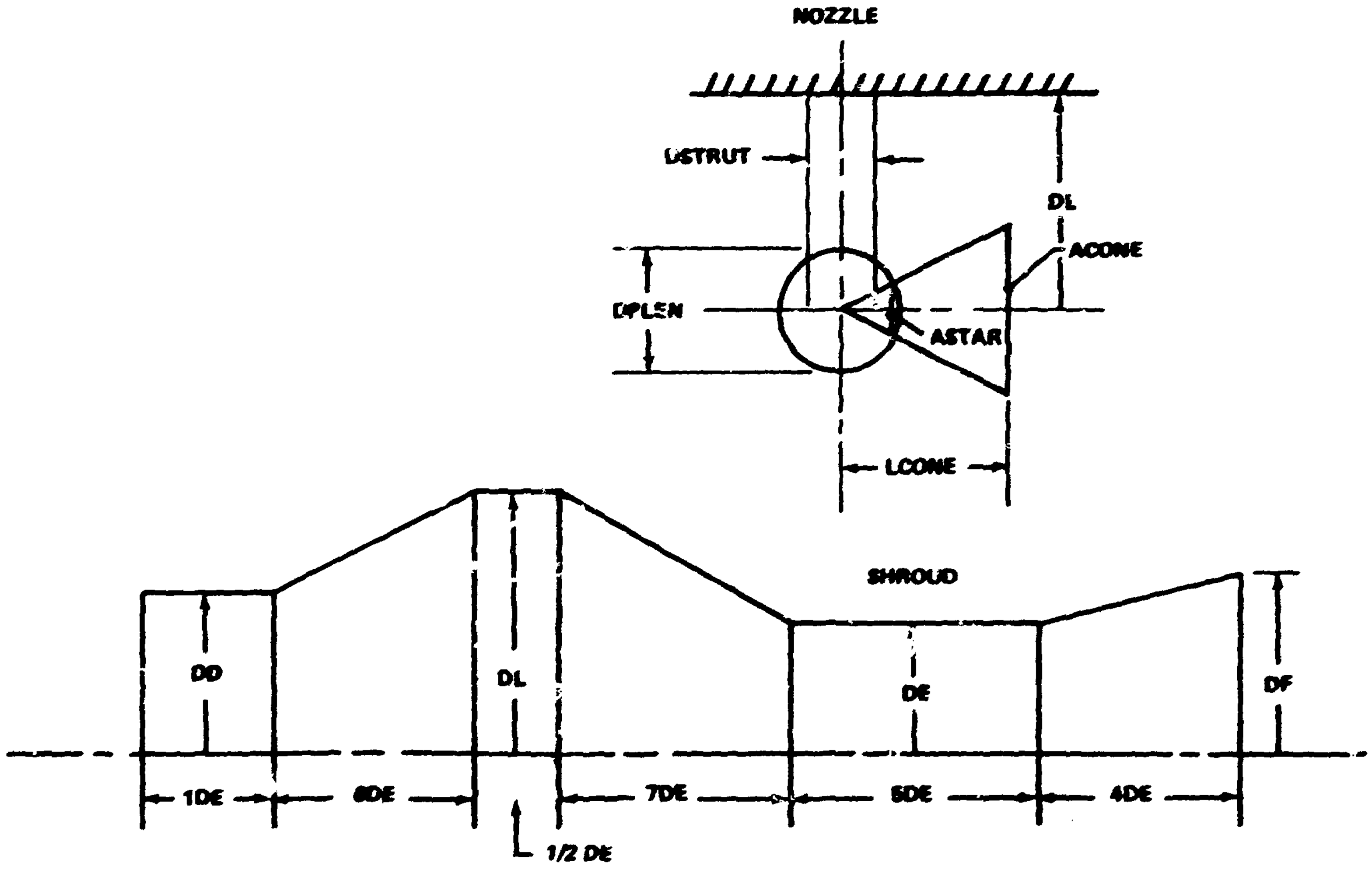

Figure 6. Subsonic-supersonic ejector nozzle and shroud.

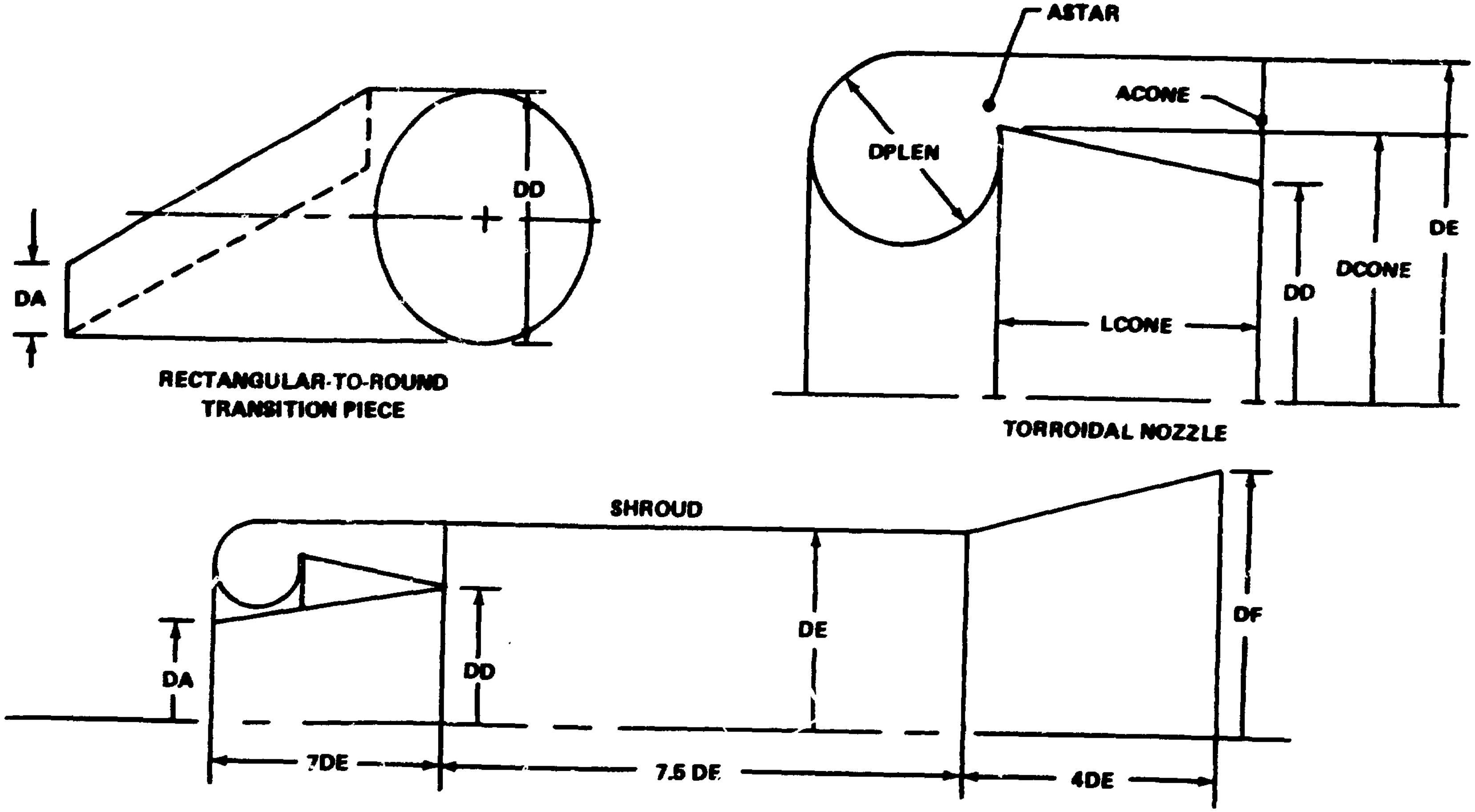

Figure 7. Supersonic-supersonic ejector transition piece, nozzle, and shroud.

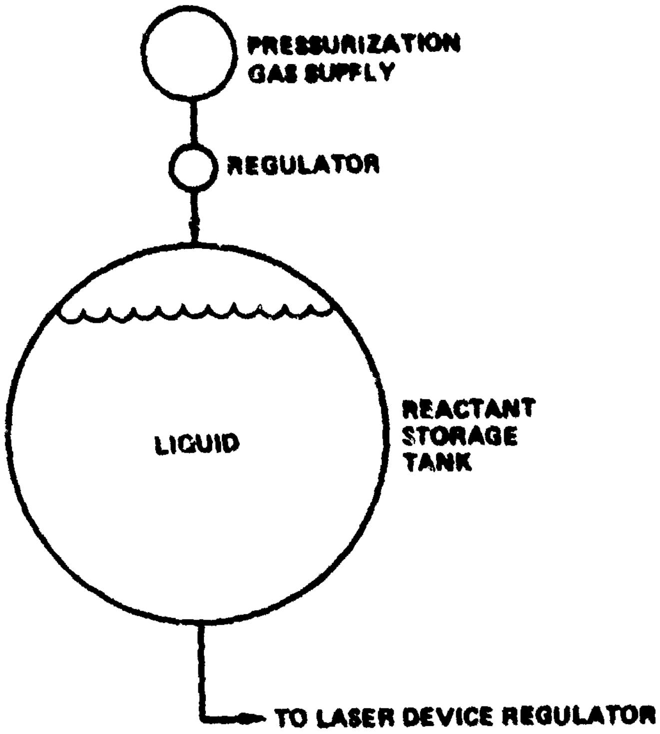

Figure 8. Pressurized gas system.

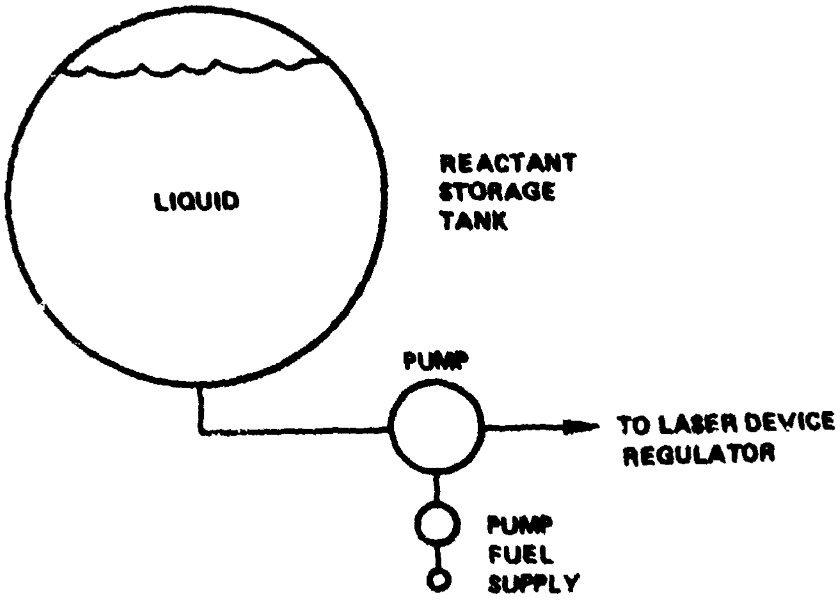

Figure 9. Pump feed system.

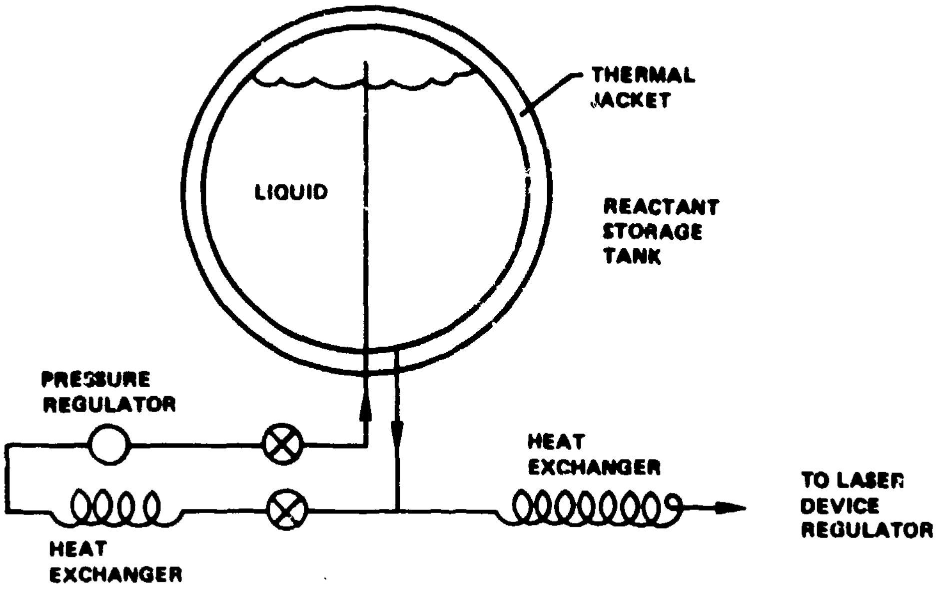

Figure 10. Heater pressurization system.

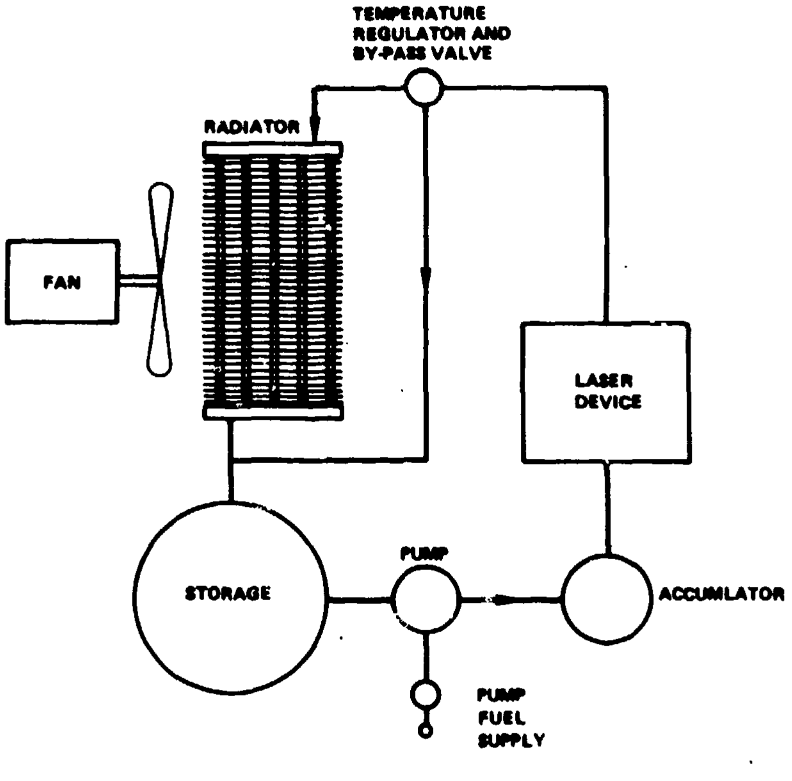

Figure 11. Radiator-fan-pump cooling system.

III. PROGRAM INPUT DATA

Inputs to CLAP are either by namelist or by alphanumeric symbols, usually "YES" or "NO" unless otherwise specified. Two example cases are given in Appendix G, one using only the built-in default values and the second demonstrating most of the input options.

A. COMBUSTION CHEMISTRY SECTION (CCS)

Inputs to CCS are fairly straightforward. The reactant mass flow rates must correspond with the area of the experimental device, AEXP, but need not be scaled for any particular laser system since only the mole fluxes are important. The area of the experimental device, AEXP, refers only to the nozzle bank area as defined in the input section for the LDS overlay.

The input variables for CCS are:

AEXP = Nozzle bank area of the experimental device [m^2].
ALPHA = Fluorine dissociation fraction.
DFORHF = Control variable such that:
= "DF" for a DF chemical laser.
= "HF" for a HF chemical laser.
N1 = Number of carbon atoms in primary combustor fuel WPR1.
N2 = Number of hydrogen (deuterium)* atoms in primary combustor fuel WPR1.
N3 = Number of nitrogen atoms in primary combustor oxidizer WPR4.
N4 = Number of fluorine atoms in primary combustor oxidizer WPR4.
WPG = Mass flow rate of mirror purge N_2 (kg/s).
WPR1 = Mass flow rate of primary combustor fuel $C_{N1}H_{N2}$ ($C_{N1}D_{N2}$) (kg/s).
WPR2 = Mass flow rate of primary combustor diluent He (kg/s).
WPR3 = Mass flow rate of primary combustor diluent N_2 (kg/s).
WPR4 = Mass flow rate of primary combustor oxidizer $N_{N3}F_{N4}$(kg/s).
WSR1 = Mass flow rate of secondary reactant D_2 (H_2) (kg/s).
WSR2 = Mass flow rate of secondary diluent He (kg/s).
WSR3 = Mass flow rate of secondary diluent N_2 (kg/s).

B. LASER DEVICE SECTION (LDS)

The inputs to LDS consist primarily of the principal device dimensions illustrated in Figures 12, 13, and 14 for the laser nozzles, nozzle bank/base, and laser cavity.

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*Compounds in parenthesis refer to HF laser chemistry.

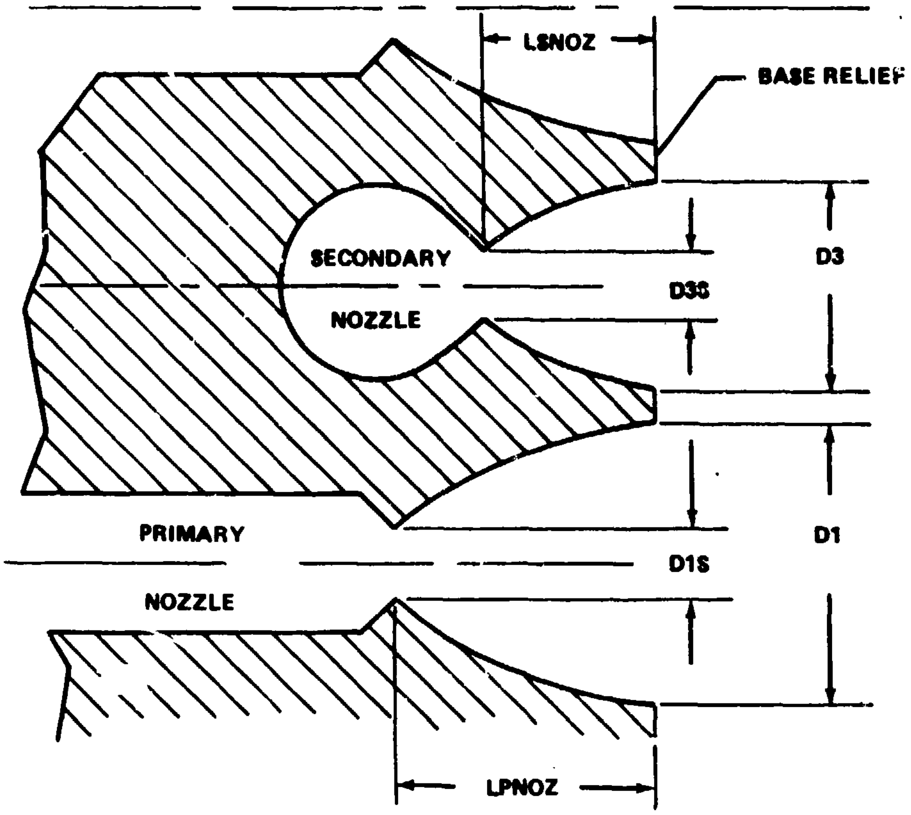

Figure 12. Laser nozzle detail.

The greatest confusion involves the difference between nozzle bank and nozzle base, and packing fraction versus bank relief fraction. Early laser demonstration devices had a nozzle array built as a single unit and termed a nozzle bank with individual nozzles separated at the face by no-flow areas termed base relief. With the advent of modular devices, several of these nozzle banks were inserted into a larger unit and separated by no-flow areas termed bank relief to form a nozzle "base." Therefore, nozzle bank area refers to the nozzle array inserts while the nozzle base area includes both nozzle banks and surrounding bank relief areas. Considering only a nozzle bank, the packing fraction is defined as:

$$\text{PKFRAC} = \frac{\text{total flow (void) area}}{\text{total area}} = \frac{\text{nozzle bank area - base relief area}}{\text{nozzle band area}} .$$

Considering the entire nozzle base, the bank relief fraction is defined as:

$$\text{BRFRAC} = \frac{\text{total area - bank relief area}}{\text{total area}} = \frac{\text{nozzle bank area}}{\text{total area}} ,$$

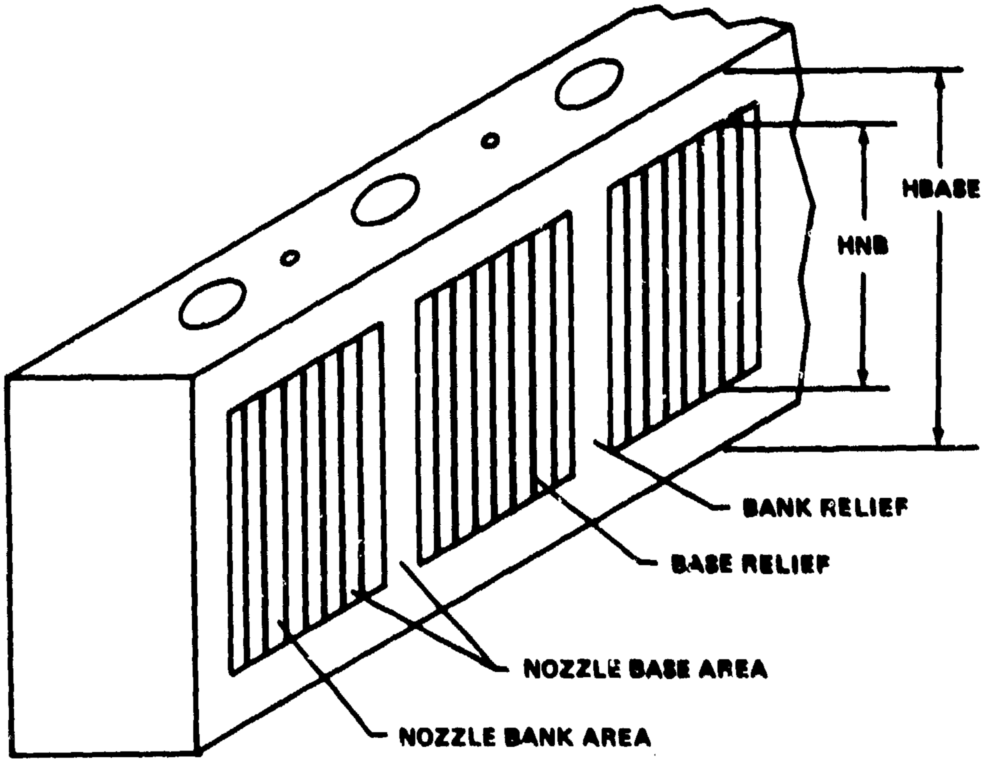

Figure 13. Laser nozzle bank/base detail.

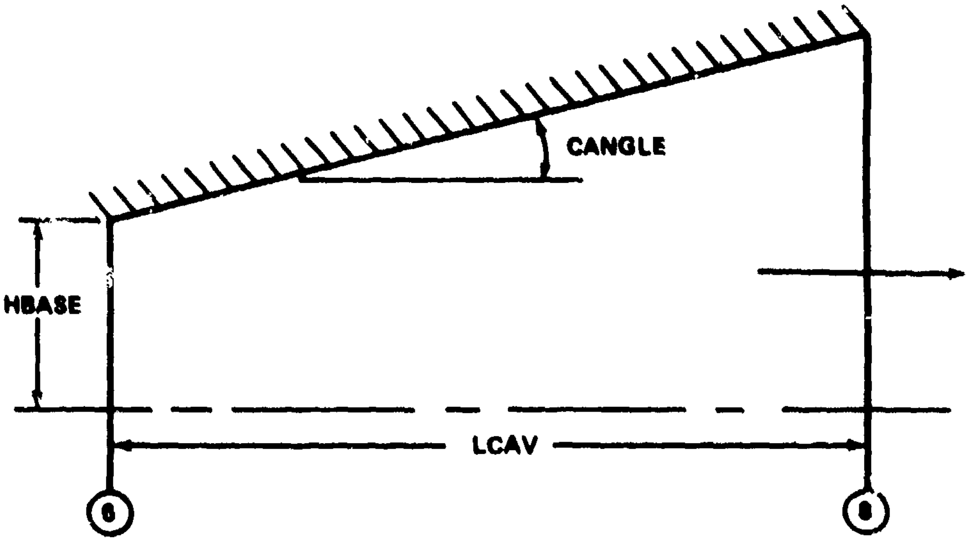

Figure 14. Laser cavity detail.

where the nozzle bank area as also used in CCS inputs includes both voids and base relief.

The input variables for the LDS overlay are:

BRFRAC = Bank relief fraction.
CANGLE = Laser cavity half-angle (rad).
D1 = Primary nozzle exit diameter (m).
D1S = Primary nozzle throat diameter (m).
D3 = Secondary nozzle exit diameter (m).
D3S = Secondary nozzle throat diameter (m)*.
GEOMPN = Primary nozzle control variable such that:
= "AX" for axisymmetric nozzles.
= "2D" for slit nozzles.
GEOMSN = Primary nozzle control variable such that:
= "AX" for axisymmetric nozzles.
= "2D" for slit nozzles.
HBASE = Height of nozzle base (m).
HNB = Height of nozzle bank (m).
LCAV = Laser cavity centerline length (m).
LDSS2 = Control variable such that:
= "P10" to specify P10 and solve for T10.
= "T10" to specify T10 and solve for P10.
LPNOZ = Centerline length of a primary nozzle from throat to exit plane (m).
LSNOZ = Centerline length of a secondary nozzle from throat to exit plane (m).
NSPNOZ = Number of secondary-to-primary nozzles.
PKFRAC = Nozzle packing fraction.
P10 = Primary combustor or nozzle stagnation pressure (Pa).
T10 = Primary combustor or nozzle stagnation temperature (°K).
T30 = Secondary nozzle stagnation temperature (°K).
T70 = Mirror purge stagnation temperature (°K).

C. PRESSURE RECOVERY SECTION (PRS)

The number of inputs to PRS depends on the particular pressure recovery system chosen but are fairly obvious from the station numbers of Figures 3, 15, 16, and 17. A full discussion of the variables ETA12 and LIMIT is given in References 2 and 9.

The input variables for the PRS overlay are:

A3A2 = Subsonic diffuser exit-to-entrance area ratio.
A7A6 = Subsonic diffuser exit-to-entrance area ratio.
EJECT = Control variable such that:
= "NO" for no pressure recovery subsystem.

---

*NOTE: D3 = D3S for constant-area, sonic nozzles.

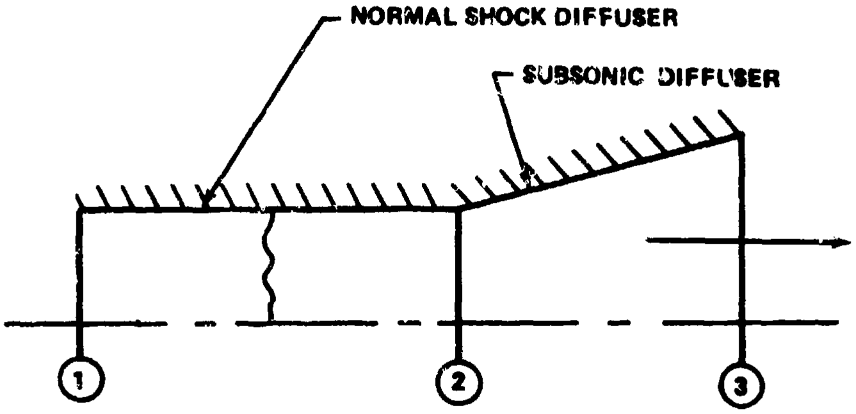

Figure 15. Supersonic-subsonic diffuser detail.

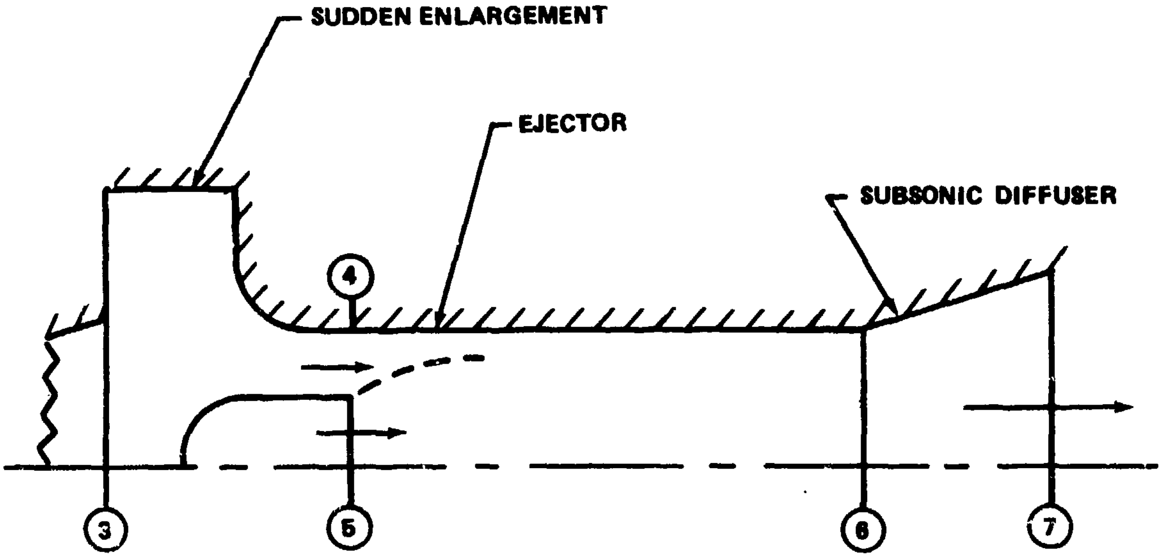

Figure 16. Constant-area, subsonic-supersonic ejector detail.

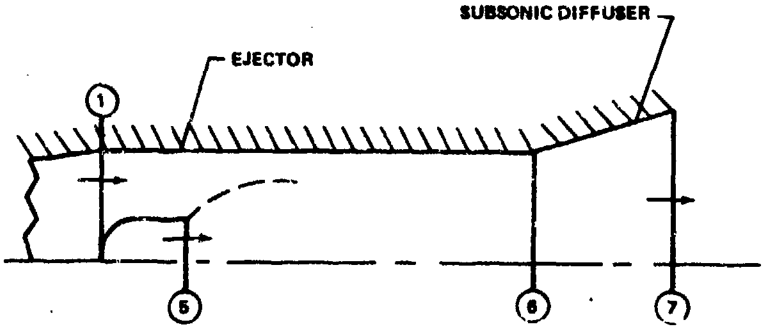

Figure 17. Constant-area, supersonic-supersonic ejector detail.

= "DIF" for a supersonic-subsonic diffuser subsystem.
= "CAE" for a constant-area, subsonic-supersonic ejector subsystem.
= "SSE" for a constant-area, supersonic-supersonic ejector subsystem.
ETA12 = Normal shock diffuser coefficient.
G5 = Specific heat ratio for the ejector primary or driver stream.
LIMIT = Control variable to set the limiting condition on constant-area, supersonic-supersonic ejector operation such that:
= "MPP" for the matched pressure point.
= "ZSP" for the Zukoski separation point.
= "ULP" for the upper limit point.
MW5 = Molecular weight of the ejector primary or driver stream (kg/kmole).
P50 = Ejector primary or driver stagnation pressure (Pa).
P7 = Ambient pressure (Pa).

D. SYSTEM CALCULATION SECTION (SCS)

Inputs to SCS provide scaling and configuration information, select an ejector driver fluid if required, and determine the storage mode for each laser reactant.

The various storage mode inputs are too numerous to list but consist entirely of simple integer inputs as illustrated in Appendix G. The storage mode selection display for each reactant is output by the computer code and requires no user action.

The input variables for the SCS overlay are:

EREACT = Alphanumberic symbol for the ejector primary or driver reactant.
= "N2H4" for a monopropellant driver.
= "IRFNA/MMH" for a bipropellant driver.
NBANK = Number of laser banks.
NEJECT = Number of ejectors per laser bank.
= 0, for the maximum allowable.
RTIME = Laser run time (s).
WPP3 = Free fluorine mass flow rate (kg/s).

IV. CONCLUSIONS AND RECOMMENDATIONS

Due to the complexity of high energy, chemical laser systems, a thorough understanding of the component interactions is required before a practical weapons system can be designed and fielded. Attempts to optimize any given component without regard to the total laser system

are likely fruitless. CLAP provides a quick, convenient, and effective means for conducting parametric studies of a total, integrated chemical laser system, thus allowing for innovation from a component standpoint while measuring total system implications.

CLAP was not meant to be an ultimate means of chemical laser system design, nor will the one-dimensional methods and empirical volume/mass relations allow it to be. Nonetheless, experience has shown that if properly used, the program will give surprisingly good quantitative as well as qualitative results; furthermore, if used with ingenuity, the program can simulate most laser device configurations including axisymmetric and slit nozzles, plane and cylindrical laser cavities, and high or low bank relief geometries.

To further develop and expand the usefulness of this computer code, a detailed description of the individual programs and subroutines will be published together with the background analysis.

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Appendix A. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)-OVERLAY MAIN

```
C***********************************************************************MAIN  0100
C*                                                                     *MAIN  0110
C*                CHEMICAL LASER ANALYSIS PROGRAM (CLAP)               *MAIN  0120
C*                                                                     *MAIN  0130
C*                     WRITTEN BY: C.L. ADAMS                          *MAIN  0140
C*                                 A.L. ADDY                           *MAIN  0150
C*                                 R.D. MASSEY                         *MAIN  0160
C*                                 C.D. MIKKELSEN                      *MAIN  0170
C*                                 G.F. MORR                           *MAIN  0180
C*                                 R.L. OGLUKIAN                       *MAIN  0190
C*                                 B.J. WALKER                         *MAIN  0200
C*                                                                     *MAIN  0210
C*                    1 JANUARY 77 - 1 JANUARY 79                      *MAIN  0220
C*                                                                     *MAIN  0230
C*                  AERODYNAMICS GROUP (DRDMI-TDK)                     *MAIN  0240
C*                  SYSTEM SIMULATION DIRECTORATE                      *MAIN  0250
C*          U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND           *MAIN  0260
C*                 REDSTONE ARSENAL, ALABAMA 35809                     *MAIN  0270
C*                                                                     *MAIN  0280
C***********************************************************************MAIN  0290
C                                                                       MAIN  0300
C***********************************************************************MAIN  0310
C*                                                                     *MAIN  0320
C*           PROGRAM CLAP REQUIRES THE FOLLOWING OVERLAYS:             *MAIN  0330
C*                                                                     *MAIN  0340
C*     MAIN          CCS           LDS           PRS           SCS     *MAIN  0350
C*                                                                     *MAIN  0360
C*          OVERLAY MAIN REQUIRES THE FOLLOWING SUBROUTINES:           *MAIN  0370
C*                                                                     *MAIN  0380
C*     OUTENG                                                          *MAIN  0390
C*                                                                     *MAIN  0400
C*          OVERLAY CCS REQUIRES THE FOLLOWING SUBROUTINES:            *MAIN  0410
C*                                                                     *MAIN  0420
C*     INCCS         OUTCCS                                            *MAIN  0430
C*                                                                     *MAIN  0440
C*                                                                     *MAIN  0450
C*          OVERLAY LDS REQUIRES THE FOLLOWING SUBROUTINES:            *MAIN  0460
C*                                                                     *MAIN  0470
C*     CAMS          CPCALC        EXPAN         INLDS         ITER    *MAIN  0480
C*     LBLAYR        LCAS          LCFS          LPNCS         LSNCS1  *MAIN  0490
C*     LSNCS2        MAAS          OUTLDS        VISC                  *MAIN  0500
C*                                                                     *MAIN  0510
C*          OVERLAY PRS REQUIRES THE FOLLOWING SUBROUTINES:            *MAIN  0520
C*                                                                     *MAIN  0530
C*     CAEFC         CAEOCV        CAEOS         INPRS         ITER    *MAIN  0540
C*     MAAS          MIN           NSDS          OUTPRS        SDS     *MAIN  0550
C*     SSFOS         SSES                                              *MAIN  0560
C*                                                                     *MAIN  0570
C*          OVERLAY SCS REQUIRES THE FOLLOWING SUBROUTINES:            *MAIN  0580
C*                                                                     *MAIN  0590
C*     INSCS         OUTSCS        VMAW          VMCS          VMC2H4  *MAIN  0600
C*     VMD2          VMF2          VMHE          VMH2          VMIRFNA *MAIN  0610
C*     VMMMH         VMNF3         VMN2          VMN2H4                *MAIN  0620
C*                                                                     *MAIN  0630
C***********************************************************************MAIN  0640
```

```
C                                                                       MAIN    0650
C                                                                       MAIN    0660
      OVERLAY(MAIN,0,0)                                                 MAIN    0670
      PROGRAM MAIN(TAPE1=512,TAPE2=512,TAPE3=512,TAPE4=512,TAPE5,TAPE6, MAIN    0680
     -TAPE20,TAPE30)                                                    MAIN    0690
C                                                                       MAIN    0700
      IMPLICIT REAL(L,N)                                                MAIN    0710
      INTEGER SCS4                                                      MAIN    0720
C                                                                       MAIN    0730
      COMMON/CCS1/CCS1                                                  MAIN    0740
      COMMON/CCS9/CCS9(4)                                               MAIN    0750
      COMMON/CCS10/CCS10(4)                                             MAIN    0760
      COMMON/CCS13/CCS13(4)                                             MAIN    0770
      COMMON/CCS14/CCS14                                                MAIN    0780
      COMMON/CCS15/CCS15                                                MAIN    0790
      COMMON/CCS16/CCS16(3)                                             MAIN    0800
C                                                                       MAIN    0810
      COMMON/LDS1/LDS1                                                  MAIN    0820
C                                                                       MAIN    0830
      COMMON/MAIN1/FAIL                                                 MAIN    0840
      COMMON/MAIN2/FLOW                                                 MAIN    0850
      COMMON/MAIN3/SETCCS                                               MAIN    0860
      COMMON/MAIN4/SETLDS                                               MAIN    0870
      COMMON/MAIN5/SETPRS                                               MAIN    0880
      COMMON/MAIN6/SETSCS                                               MAIN    0890
C                                                                       MAIN    0900
      COMMON/PRS1/PRS1                                                  MAIN    0910
C                                                                       MAIN    0920
      COMMON/SCS4/SCS4(10)                                              MAIN    0930
C                                                                       MAIN    0940
      DATA CCS/3HCCS/,LDS/3HLDS/,PRS/3HPRS/,SCS/3HSCS/                  MAIN    0950
      DATA SETCCS/3HYES/,SETLDS/3HYES/,SETPRS/3HYES/,SETSCS/3HYES/      MAIN    0960
      DATA CHOKE/5HCHOKE/,NO/2HNO/,RECALL/6HRECALL/,YES/3HYES/          MAIN    0970
C                                                                       MAIN    0980
      NAMELIST/NLCCS/AEXP,ALPHA,N1,N2,N3,N4,WP6,WPR1,WPR2,WPR3,WPR4,    MAIN    0990
     -WSR1,WSR2,WSR3                                                    MAIN    1000
      NAMELIST/NLLDS/BRFRAC,CANGLE,D1,D1S,D3,D3S,HNB,LCAV,LPNOZ,LSNOZ,  MAIN    1010
     -NSPNOZ,PKFRAC,P10,T10,T30,T70                                     MAIN    1020
      NAMELIST/NLPRS/A3A2,A7A6,ETA12,GS,MWS,P50,P7,T50                  MAIN    1030
      NAMELIST/NLSCS/NBANK,NEJECT,RTIME,WPP3                            MAIN    1040
C                                                                       MAIN    1050
C                                                                       MAIN    1060
C***********************************************************************MAIN    1070
C*                                                                     *MAIN    1080
C*                       COMBUSTION CHEMISTRY SECTION                  *MAIN    1090
C*                                                                     *MAIN    1100
C***********************************************************************MAIN    1110
C                                                                       MAIN    1120
C                                                                       MAIN    1130
      CALL CONNEC(5)                                                    MAIN    1140
      CALL CONNEC(6)                                                    MAIN    1150
101   FAIL=NO                                                           MAIN    1160
      CALL OVERLAY(CCS,1,0,RECALL)                                      MAIN    1170
C                                                                       MAIN    1180
C                                                                       MAIN    1190
```

```
C***********************************************************************
C*                                                                     *
C*                        LASER DEVICE SECTION                         *
C*                                                                     *
C***********************************************************************
C
C
      CALL OVERLAY(LDS,2,0,RECALL)
      IF(FAIL.EQ.YES) GO TO 103
      IF(FLOW.EQ.CHOKE) GO TO 102
C
C
C***********************************************************************
C*                                                                     *
C*                     PRESSURE RECOVERY SECTION                       *
C*                                                                     *
C***********************************************************************
C
C
      CALL OVERLAY(PRS,3,0,RECALL)
      IF(FAIL.EQ.YES) GO TO 103
C
C
C***********************************************************************
C*                                                                     *
C*                     SYSTEM CALCULATION SECTION                      *
C*                                                                     *
C***********************************************************************
C
C
      CALL OVERLAY(SCS,4,0,RECALL)
      IF(FAIL.EQ.YES) GO TO 103
C
C
C***********************************************************************
C*                                                                     *
C*              OUTPUT RESULTS IN MIXED ENGINEERING UNITS              *
C*                                                                     *
C***********************************************************************
C
C
102   CALL OUTENG
C
C***********************************************************************
C*                                                                     *
C*                          CONTROL SECTION                            *
C*                                                                     *
C***********************************************************************
C
C
103   WRITE(6,104)
      READ(5,105)RUN
      IF(RUN.EQ.YES) GO TO 101
104   FORMAT(*1*,T2,*TO RESTART PROGRAM ENTER "YES"*,/,T2,*TO STOP PROGR
     -AM ENTER "NO"*)
```

```
105   FORMAT(A3)                                                        MAIN   1750
C                                                                       MAIN   1760
C                                                                       MAIN   1770
C***********************************************************************MAIN   1780
C*                                                                     *MAIN   1790
C*                     DUMMY READ/WRITE STATEMENTS                     *MAIN   1800
C*                                                                     *MAIN   1810
C***********************************************************************MAIN   1820
C                                                                       MAIN   1830
C                                                                       MAIN   1840
      STOP                                                              MAIN   1850
106   READ(1)                                                           MAIN   1860
      WRITE(1)                                                          MAIN   1870
      READ(5,NLCCS)                                                     MAIN   1880
      READ(5,NLLDS)                                                     MAIN   1890
      READ(5,NLPRS)                                                     MAIN   1900
      READ(5,NLSCS)                                                     MAIN   1910
      END                                                               MAIN   1920
```

```
      SUBROUTINE OUTENG                                                 OUTENG 0100
C                                                                       OUTENG 0110
C                                                                       OUTENG 0120
C***********************************************************************OUTENG 0130
C*                                                                     *OUTENG 0140
C*                        OUTPUT SUBROUTINE (OUTENG)                   *OUTENG 0150
C*                                                                     *OUTENG 0160
C***********************************************************************OUTENG 0170
C                                                                       OUTENG 0180
C***********************************************************************OUTENG 0190
C*                                                                     *OUTENG 0200
C*   SUBROUTINE  OUTENG PRINTS THE RESULTS OF PROGRAM  CLAP IN MIXED   *OUTENG 0210
C*   ENGINEERING UNITS ON TERMINALS WITH A MINIMUM OF 132 CHARACTERS   *OUTENG 0220
C*   PER LINE.                                                         *OUTENG 0230
C*                                                                     *OUTENG 0240
C***********************************************************************OUTENG 0250
C                                                                       OUTENG 0260
C                                                                       OUTENG 0270
      IMPLICIT REAL(L,M,N)                                              OUTENG 0280
C                                                                       OUTENG 0290
      INTEGER NRANK,NEJECT,N1,N2,N3,N4                                  OUTENG 0300
C                                                                       OUTENG 0310
      COMMON/CCS2/CCS1,ALPHA,CCS2(8)                                    OUTENG 0320
C                                                                       OUTENG 0330
      COMMON/CCS3/DFORMF                                                OUTENG 0340
C                                                                       OUTENG 0350
      COMMON/CCS4/CCS3                                                  OUTENG 0360
C                                                                       OUTENG 0370
      COMMON/CCS5/N1,N2,N3,N4                                           OUTENG 0380
C                                                                       OUTENG 0390
      COMMON/CCS6/OMEGA,OMEGTRW,PSIC,PSIL,PSILTRW,RC,RLF,WFCP1,WFCP2,   OUTENG 0400
     -WFCP3,WFCP4,WFCP5,WFCP6                                           OUTENG 0410
C                                                                       OUTENG 0420
      COMMON/CCS7/CCS4                                                  OUTENG 0430
C                                                                       OUTENG 0440
      COMMON/CCS8/RL                                                    OUTENG 0450
C                                                                       OUTENG 0460
      COMMON/CCS11/W7W2                                                 OUTENG 0470
C                                                                       OUTENG 0480
      COMMON/CCS12/XFCP1(2),XFCP2(2),XFCP3(2),XFCP4(2),XFCP5(2),XFCP6(2)OUTENG 0490
C                                                                       OUTENG 0500
      COMMON/LDS2/LDS1(4),GEOMPN,GEOMSN,LDSS2,LDS2(2),NSPNOZ,PKFRAC,    OUTENG 0510
     -LDS3(4)                                                           OUTENG 0520
C                                                                       OUTENG 0530
      COMMON/LDS3/LDS4,A1A1SE,A1A1SG,LDS5(2),A3A3SE,A3A3SG,LDS6(35),RE1,OUTENG 0540
     -RE3,RE8,LDS7(23),W5W2,W6W2,W8W2,LDS8,X4X2,X5X2,X6X2,X7X2,X8X2     OUTENG 0550
C                                                                       OUTENG 0560
      COMMON/LDS4/LDS9(10)                                              OUTENG 0570
C                                                                       OUTENG 0580
      COMMON/LDS5/BRFRAC,LDS10(4)                                       OUTENG 0590
C                                                                       OUTENG 0600
      COMMON/LDS6/LDS11(2),W4W2                                         OUTENG 0610
C                                                                       OUTENG 0620
      COMMON/MAIN2/FLOW                                                 OUTENG 0630
C                                                                       OUTENG 0640
```

```
      COMMON/PRS2/PRS1(4),ETA23,ETA67,PRS2(48),W2W1,PRS3,W4W1,W6W1,W7W1,
     -X2X1,PRS4,X4X1,X5X1,X6X1,X7X1
C
      COMMON/PRS3/A3A2,A7A6,ETA12,LIMIT,PRS5(3)
C
      COMMON/PRS4/PRS6(3),W5W1
C
      COMMON/PRS5/EJECT
C
      COMMON/PRS6/PRS7(2)
C
      COMMON/SCS1/SCSS2
C
      COMMON/SCS2/EREACT,NRANK,NEJECT,RTIME,SCS1
C
      COMMON/SCS3/SCS2(47)
C
      COMMON/SC35/STMODE(10,10)
C
      DATA CAE/3HCAE/,CHOKE/5HCHOKE/,DF/2HDF/,HF/2HHF/,NPP/3HNPP/,
     -NO/2HNO/,SEP/3HSEP/,SSE/3HSSE/,ULP/3HULP/,ZSP/3HZSP/
C
C
C***********************************************************************
C*                                                                     *
C*                    COMBUSTION CHEMISTRY SECTION                     *
C*                                                                     *
C***********************************************************************
C
C
      AEXP=CCS1/6.4516E-04
      FDAA=CCS3*6.45160E-01
      Q=CCS4*2.39006E-04
      WP0=CCS2(1)*1.0E+03
      WPR1=CCS2(2)*1.0E+03
      WPR2=CCS2(3)*1.0E+03
      WPR3=CCS2(4)*1.0E+03
      WPR4=CCS2(5)*1.0E+03
      WSR1=CCS2(6)*1.0E+03
      WSR2=CCS2(7)*1.0E+03
      WSR3=CCS2(8)*1.0E+03
C
C
      CALL DATE(RDATE)
      WRITE(30,201)RDATE
      IF(DFORHF.EQ.DF) WRITE(30,202)AEXP,ALPHA,DFORHF,N1,N2,N3,N4,WP0,
     -WPR1,N1,N2,WPR2,WPR3,WPR4,N3,N4,WSR1,WSR2,WSR3
      IF(DFORHF.EQ.HF) WRITE(30,203)AEXP,ALPHA,DFORHF,N1,N2,N3,N4,WP0,
     -WPR1,N1,N2,WPR2,WPR3,WPR4,N3,N4,WSR1,WSR2,WSR3
      WRITE(30,204)FDAA,OMEGA,OMEGTRW,PSIC,PSIL,PSILTRW,Q,RC,RL,RLF
      IF(DFORHF.EQ.DF) WRITE(30,205)WFCP1,XFCP1(2),WFCP2,XFCP2(2),WFCP3,
     -XFCP3(2),WFCP4,XFCP4(2),WFCP5,XFCP5(2),WFCP6,XFCP6(2)
      IF(DFORHF.EQ.HF) WRITE(30,206)WFCP1,XFCP1(2),WFCP2,XFCP2(2),WFCP3,
     -XFCP3(2),WFCP4,XFCP4(2),WFCP5,XFCP5(2),WFCP6,XFCP6(2)
C
```

```
C                                                                       OUTENG 1200
C***********************************************************************OUTENG 1210
C*                                                                     *OUTENG 1220
C*                            LASER DEVICE SECTION                     *OUTENG 1230
C*                                                                     *OUTENG 1240
C***********************************************************************OUTENG 1250
C                                                                       OUTENG 1260
C                                                                       OUTENG 1270
      A1=LDS4*7.03066E+02                                               OUTENG 1280
      A2=LDS5(1)*7.03066E+02                                            OUTENG 1290
      A3=LDS5(2)*7.03066E+02                                            OUTENG 1300
      A4=LDS6(1)*7.03066E+02                                            OUTENG 1310
      A5=LDS6(2)*7.03066E+02                                            OUTENG 1320
      A6=LDS6(3)*7.03066E+02                                            OUTENG 1330
      A8=LDS9(1)*7.03066E+02                                            OUTENG 1340
      CANGLE=LDS10(1)/1.7453292519943E-02                               OUTENG 1350
      D1=LDS1(1)/2.54E-02                                               OUTENG 1360
      D1S=LDS1(2)/2.54E-02                                              OUTENG 1370
      D3=LDS1(3)/2.54E-02                                               OUTENG 1380
      D3S=LDS1(4)/2.54E-02                                              OUTENG 1390
      G1=LDS6(4)                                                        OUTENG 1400
      G2=LDS6(5)                                                        OUTENG 1410
      G3=LDS6(6)                                                        OUTENG 1420
      G4=LDS6(7)                                                        OUTENG 1430
      G5=LDS6(8)                                                        OUTENG 1440
      G6=LDS6(9)                                                        OUTENG 1450
      G7=LDS6(10)                                                       OUTENG 1460
      G8=LDS9(2)                                                        OUTENG 1470
      HBASE=LDS10(2)/2.54E-02                                           OUTENG 1480
      HNB=LDS10(3)/2.54E-02                                             OUTENG 1490
      LCAV=LDS10(4)/2.54E-02                                            OUTENG 1500
      LPNOZ=LDS2(1)/2.54E-02                                            OUTENG 1510
      LSNOZ=LDS2(2)/2.54E-02                                            OUTENG 1520
      LSEP=LDS6(11)/2.54E-02                                            OUTENG 1530
      MW1=LDS6(12)                                                      OUTENG 1540
      MW2=LDS6(13)                                                      OUTENG 1550
      MW3=LDS6(14)                                                      OUTENG 1560
      MW4=LDS6(15)                                                      OUTENG 1570
      MW5=LDS6(16)                                                      OUTENG 1580
      MW6=LDS6(17)                                                      OUTENG 1590
      MW7=LDS6(18)                                                      OUTENG 1600
      MW8=LDS9(3)                                                       OUTENG 1610
      M1=LDS6(19)                                                       OUTENG 1620
      M2=LDS6(20)                                                       OUTENG 1630
      M3=LDS6(21)                                                       OUTENG 1640
      M4=LDS6(22)                                                       OUTENG 1650
      M5=LDS6(23)                                                       OUTENG 1660
      M6=LDS6(24)                                                       OUTENG 1670
      M8=LDS9(4)                                                        OUTENG 1680
      NPNOZ=LDS6(25)*0.45359                                            OUTENG 1690
      NSNOZ=LDS6(26)*0.45359                                            OUTENG 1700
      P1=LDS6(27)/1.333224E+02                                          OUTENG 1710
      P10=LDS3(1)/6.8947572E+03                                         OUTENG 1720
      P2=LDS6(28)/1.333224E+02                                          OUTENG 1730
      P20=LDS11(1)/6.8947572E+03                                        OUTENG 1740
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      P3=LDS6(29)/1.333224E+02                                          OUTENG 1750
      P30=LDS6(30)/6.8947572E+03                                        OUTENG 1760
      P4=LDS6(31)/1.333224E+02                                          OUTENG 1770
      P40=LDS11(2)/6.8947572E+03                                        OUTENG 1780
      P5=LDS6(32)/1.333224E+02                                          OUTENG 1790
      P50=LDS6(33)/1.333224E+02                                         OUTENG 1800
      P6=LDS6(34)/1.333224E+02                                          OUTENG 1810
      P60=LDS6(35)/1.333224E+02                                         OUTENG 1820
      P8=LDS9(5)/1.333224E+02                                           OUTENG 1830
      P80=LDS9(6)/1.333224E+02                                          OUTENG 1840
      R1=LDS7(1)/1.0E+03                                                OUTENG 1850
      R10=LDS7(2)/1.0E+03                                               OUTENG 1860
      R2=LDS7(3)/1.0E+03                                                OUTENG 1870
      R20=LDS7(4)/1.0E+03                                               OUTENG 1880
      R3=LDS7(5)/1.0E+03                                                OUTENG 1890
      R30=LDS7(6)/1.0E+03                                               OUTENG 1900
      R4=LDS7(7)/1.0E+03                                                OUTENG 1910
      R40=LDS7(8)/1.0E+03                                               OUTENG 1920
      R5=LDS7(9)/1.0E+03                                                OUTENG 1930
      R50=LDS7(10)/1.0E+03                                              OUTENG 1940
      R6=LDS7(11)/1.0E+03                                               OUTENG 1950
      R60=LDS7(12)/1.0E+03                                              OUTENG 1960
      R8=LDS9(7)/1.0E+03                                                OUTENG 1970
      R80=LDS9(8)/1.0E+03                                               OUTENG 1980
      T1=LDS7(13)                                                       OUTENG 1990
      T10=LDS3(2)                                                       OUTENG 2000
      T2=LDS7(14)                                                       OUTENG 2010
      T20=LDS7(15)                                                      OUTENG 2020
      T3=LDS7(16)                                                       OUTENG 2030
      T30=LDS3(3)                                                       OUTENG 2040
      T4=LDS7(17)                                                       OUTENG 2050
      T40=LDS7(18)                                                      OUTENG 2060
      T5=LDS7(19)                                                       OUTENG 2070
      T50=LDS7(20)                                                      OUTENG 2080
      T6=LDS7(21)                                                       OUTENG 2090
      T60=LDS7(22)                                                      OUTENG 2100
      T70=LDS3(4)                                                       OUTENG 2110
      T8=LDS9(9)                                                        OUTENG 2120
      T80=LDS9(10)                                                      OUTENG 2130
      W3W1=LDS7(23)                                                     OUTENG 2140
      X3X1=LDS8                                                         OUTENG 2150
C                                                                       OUTENG 2160
C                                                                       OUTENG 2170
      WRITE(30,301)                                                     OUTENG 2180
      IF(LDSS2.EQ.3HP10) WRITE(30,302)BRFRAC,CANGLE,D1,D1S,D3,D3S,      OUTENG 2190
     -GEOMPN,GEOMSN,HBASE,HNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T30,T70OUTENG 2200
      IF(LDSS2.EQ.3HT10) WRITE(30,303)BRFRAC,CANGLE,D1,D1S,D3,D3S,      OUTENG 2210
     -GEOMPN,GEOMSN,HBASE,HNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,T10,T30,T70OUTENG 2220
      WRITE(30,304)A1,A1A1SE,A1A1SG,G1,MW1,M1,NPNOZ,P1,P10,RE1,R1,R10,  OUTENG 2230
     -T1,T10                                                            OUTENG 2240
      WRITE(30,305)A2,G2,MW2,M2,P2,P20,R2,R20,T2,T20                    OUTENG 2250
      WRITE(30,306)A3,A3A3SE,A3A3SG,G3,MW3,M3,NSNOZ,P3,P30,RE3,R3,R30,  OUTENG 2260
     -T3,T30,W3W1,X3X1                                                  OUTENG 2270
      WRITE(30,307)A4,G4,MW4,M4,P4,P40,R4,R40,T4,T40,W4W2,X4X2          OUTENG 2280
      WRITE(30,308)A5,G5,MW5,M5,P5,P50,R5,R50,T5,T50,W5W2,X5X2          OUTENG 2290
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      WRITE(30,309)A6,G6,MW6,M6,P6,P60,R6,R60,T6,T60,W6W2,X6X2          OUTENG 2300
      WRITE(30,310)G7,MW7,T70,W7W2,X7X2                                 OUTENG 2310
      IF(FLOW.EQ.SEP) GO TO 101                                         OUTENG 2320
      IF(FLOW.EQ.CHOKE) GO TO 102                                       OUTENG 2330
      WRITE(30,311)A8,G8,MW8,M8,P8,P80,RE8,R8,R80,T8,T80,W8W2,X8X2      OUTENG 2340
      GO TO 103                                                         OUTENG 2350
101   WRITE(30,312)                                                     OUTENG 2360
      WRITE(30,313)A8,G8,LSEP,MW8,M8,P8,P80,RE8,R8,R80,T8,T80,W8W2,X8X2 OUTENG 2370
      GO TO 103                                                         OUTENG 2380
102   WRITE(30,314)                                                     OUTENG 2390
      RETURN                                                            OUTENG 2400
C                                                                       OUTENG 2410
C                                                                       OUTENG 2420
C***********************************************************************OUTENG 2430
C*                                                                     *OUTENG 2440
C*                      PRESSURE RECOVERY SECTION                      *OUTENG 2450
C*                                                                     *OUTENG 2460
C***********************************************************************OUTENG 2470
C                                                                       OUTENG 2480
C                                                                       OUTENG 2490
103   IF(EJECT.EQ.NO) GO TO 109                                         OUTENG 2500
      A1=LDS9(1)*7.03066E+02                                            OUTENG 2510
      A2=PRS1(1)*7.03066E+02                                            OUTENG 2520
      A3=PRS1(2)*7.03066E+02                                            OUTENG 2530
      A4=PRS1(3)*7.03066E+02                                            OUTENG 2540
      A5=PRS6(1)*7.03066E+02                                            OUTENG 2550
      A6=PRS6(2)*7.03066E+02                                            OUTENG 2560
      A7=PRS1(4)*7.03066E+02                                            OUTENG 2570
      G1=LDS9(2)                                                        OUTENG 2580
      G2=PRS2(1)                                                        OUTENG 2590
      G3=PRS2(2)                                                        OUTENG 2600
      G4=PRS2(3)                                                        OUTENG 2610
      G5=PRS7(1)                                                        OUTENG 2620
      G6=PRS2(4)                                                        OUTENG 2630
      G7=PRS2(5)                                                        OUTENG 2640
      MW1=LDS9(3)                                                       OUTENG 2650
      MW2=PRS2(6)                                                       OUTENG 2660
      MW3=PRS2(7)                                                       OUTENG 2670
      MW4=PRS2(8)                                                       OUTENG 2680
      MW5=PRS5(1)                                                       OUTENG 2690
      MW6=PRS2(9)                                                       OUTENG 2700
      MW7=PRS2(10)                                                      OUTENG 2710
      M1=LDS9(4)                                                        OUTENG 2720
      M2=PRS2(11)                                                       OUTENG 2730
      M3=PRS2(12)                                                       OUTENG 2740
      M4=PRS2(13)                                                       OUTENG 2750
      M5=PRS6(3)                                                        OUTENG 2760
      M6=PRS2(14)                                                       OUTENG 2770
      M7=PRS2(15)                                                       OUTENG 2780
      P1=LDS9(5)/1.333224E+02                                           OUTENG 2790
      P10=LDS9(6)/1.333224E+02                                          OUTENG 2800
      P2=PRS2(16)/1.333224E+02                                          OUTENG 2810
      P20=PRS2(17)/1.333224E+02                                         OUTENG 2820
      P3=PRS2(18)/1.333224E+02                                          OUTENG 2830
      P30=PRS2(19)/1.333224E+02                                         OUTENG 2840
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      P4=PRS2(20)/1.333224E+02                                          OUTENG 2850
      P40=PRS2(21)/1.333224E+02                                         OUTENG 2860
      P5=PRS2(22)/1.333224E+02                                          OUTENG 2870
      P50=PRS7(2)/6.894757E+03                                          OUTENG 2880
      P6=PRS2(23)/1.333224E+02                                          OUTENG 2890
      P60=PRS2(24)/1.333224E+02                                         OUTENG 2900
      P7=PRS5(2)/1.333224E+02                                           OUTENG 2910
      P70=PRS2(25)/1.333224E+02                                         OUTENG 2920
      R1=LDS9(7)/1.0E+03                                                OUTENG 2930
      R10=LDS9(8)/1.0E+03                                               OUTENG 2940
      R2=PRS2(26)/1.0E+03                                               OUTENG 2950
      R20=PRS2(27)/1.0E+03                                              OUTENG 2960
      R3=PRS2(28)/1.0E+03                                               OUTENG 2970
      R30=PRS2(29)/1.0E+03                                              OUTENG 2980
      R4=PRS2(30)/1.0E+03                                               OUTENG 2990
      R40=PRS2(31)/1.0E+03                                              OUTENG 3000
      R5=PRS2(32)/1.0E+03                                               OUTENG 3010
      R50=PRS2(33)/1.0E+03                                              OUTENG 3020
      R6=PRS2(34)/1.0E+03                                               OUTENG 3030
      R60=PRS2(35)/1.0E+03                                              OUTENG 3040
      R7=PRS2(36)/1.0E+03                                               OUTENG 3050
      R70=PRS2(37)/1.0E+03                                              OUTENG 3060
      T1=LDS9(9)                                                        OUTENG 3070
      T10=LDS9(10)                                                      OUTENG 3080
      T2=PRS2(38)                                                       OUTENG 3090
      T20=PRS2(39)                                                      OUTENG 3100
      T3=PRS2(40)                                                       OUTENG 3110
      T30=PRS2(41)                                                      OUTENG 3120
      T4=PRS2(42)                                                       OUTENG 3130
      T40=PRS2(43)                                                      OUTENG 3140
      T5=PRS2(44)                                                       OUTENG 3150
      T50=PRS5(3)                                                       OUTENG 3160
      T6=PRS2(45)                                                       OUTENG 3170
      T60=PRS2(46)                                                      OUTENG 3180
      T7=PRS2(47)                                                       OUTENG 3190
      T70=PRS2(48)                                                      OUTENG 3200
      W3W1=PRS3                                                         OUTENG 3210
      X3X1=PRS4                                                         OUTENG 3220
C                                                                       OUTENG 3230
C                                                                       OUTENG 3240
      WRITE(30,401)                                                     OUTENG 3250
      IF(EJECT.EQ.CAE) GO TO 104                                        OUTENG 3260
      IF(EJECT.EQ.SSE) GO TO 105                                        OUTENG 3270
      WRITE(30,402)A3A2,EJECT,ETA12                                     OUTENG 3280
      WRITE(30,405)                                                     OUTENG 3290
      GO TO 106                                                         OUTENG 3300
104   WRITE(30,403)A3A2,A7A6,EJECT,ETA12,G5,MW5,P50,P7,T50              OUTENG 3310
      WRITE(30,405)                                                     OUTENG 3320
      GO TO 106                                                         OUTENG 3330
105   WRITE(30,404)A7A6,EJECT,G5,LIMIT,MW5,P50,P7,T50                   OUTENG 3340
      WRITE(30,406)                                                     OUTENG 3350
106   WRITE(30,407)A1,G1,MW1,M1,P1,P10,R1,R10,T1,T10                    OUTENG 3360
      IF(EJECT.EQ.SSE) GO TO 107                                        OUTENG 3370
      WRITE(30,408)A2,ETA12,G2,MW2,M2,P2,P20,R2,R20,T2,T20,W2W1,X2X1    OUTENG 3380
      WRITE(30,409)                                                     OUTENG 3390
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      IF(EJECT.EQ.CAE) WRITE(30,410)                                    OUTENG 3400
      WRITE(30,411)A3,ETA23,G3,MW3,M3,P3,P30,R3,R30,T3,T30,W3W1,X3X1    OUTENG 3410
      IF(EJECT.NE.CAE) RETURN                                           OUTENG 3420
      WRITE(30,412)A4,G4,MW4,M4,P4,P40,R4,R40,T4,T40,W4W1,X4X1          OUTENG 3430
      WRITE(30,413)                                                     OUTENG 3440
      GO TO 108                                                         OUTENG 3450
107   IF(LIMIT.EQ.ULP) WRITE(30,414)                                    OUTENG 3460
      IF(LIMIT.EQ.ZSP) WRITE(30,415)                                    OUTENG 3470
      IF(LIMIT.EQ.MPP) WRITE(30,416)                                    OUTENG 3480
      WRITE(30,417)                                                     OUTENG 3490
108   WRITE(30,418)A5,G5,MW5,M5,P5,P50,R5,R50,T5,T50,W5W1,X5X1          OUTENG 3500
      IF(EJECT.EQ.CAE) WRITE(30,419)                                    OUTENG 3510
      IF(EJECT.EQ.SSE) WRITE(30,420)                                    OUTENG 3520
      WRITE(30,421)A6,G6,MW6,M6,P6,P60,R6,R60,T6,T60,W6W1,X6X1          OUTENG 3530
      WRITE(30,422)A7,ETA67,G7,MW7,M7,P7,P70,R7,R70,T7,T70,W7W1,X7X1    OUTENG 3540
C                                                                       OUTENG 3550
C                                                                       OUTENG 3560
C***********************************************************************OUTENG 3570
C*                                                                     *OUTENG 3580
C*                       SYSTEM CALCULATION SECTION                    *OUTENG 3590
C*                                                                     *OUTENG 3600
C***********************************************************************OUTENG 3610
C                                                                       OUTENG 3620
C                                                                       OUTENG 3630
109   IF(SCSS2.EQ.NO) RETURN                                            OUTENG 3640
      HBXDEV=SCS2(1)/2.54E-02                                           OUTENG 3650
      LBXDEV=SCS2(2)/2.54E-02                                           OUTENG 3660
      LLDS=SCS2(3)/2.54E-02                                             OUTENG 3670
      LPRS=SCS2(4)/2.54E-02                                             OUTENG 3680
      MAW=SCS2(5)/0.45359237                                            OUTENG 3690
      MBASE=SCS2(6)/0.45359237                                          OUTENG 3700
      MCAV=SCS2(7)/0.45359237                                           OUTENG 3710
      MCB=SCS2(8)/0.45359237                                            OUTENG 3720
      MCS=SCS2(9)/0.45359237                                            OUTENG 3730
      MDS=SCS2(10)/0.45359237                                           OUTENG 3740
      MEJECT=SCS2(11)/0.45359237                                        OUTENG 3750
      MELINE=SCS2(12)/0.45359237                                        OUTENG 3760
      MERREG=SCS2(13)/0.45359237                                        OUTENG 3770
      MERT=SCS2(14)/0.45359237                                          OUTENG 3780
      MINJ=SCS2(15)/0.45359237                                          OUTENG 3790
      MLDHDW=SCS2(16)/0.45359237                                        OUTENG 3800
      MLDS=SCS2(17)/0.45359237                                          OUTENG 3810
      MLLINE=SCS2(18)/0.45359237                                        OUTENG 3820
      MLRREG=SCS2(19)/0.45359237                                        OUTENG 3830
      MLRT=SCS2(20)/0.45359237                                          OUTENG 3840
      MMISC=SCS2(21)/0.45359237                                         OUTENG 3850
      MOPT=SCS2(22)/0.45359237                                          OUTENG 3860
      MPRHDW=SCS2(23)/0.45359237                                        OUTENG 3870
      MPRS=SCS2(24)/0.45359237                                          OUTENG 3880
      MSUBD=SCS2(25)/0.45359237                                         OUTENG 3890
      MSUPD=SCS2(26)/0.45359237                                         OUTENG 3900
      MTOTAL=SCS2(27)/0.45359237                                        OUTENG 3910
      VAW=SCS2(28)/2.8316846592E-02                                     OUTENG 3920
      VBXDEV=SCS2(29)/2.8316846592E-02                                  OUTENG 3930
      VCAV=SCS2(30)/2.8316846592E-02                                    OUTENG 3940
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      VCOMB=SCS2(31)/2.8316846592E-02                                   OUTENG 3950
      VCS=SCS2(32)/2.8316846592E-02                                     OUTENG 3960
      VEJECT=SCS2(33)/2.8316846592E-02                                  OUTENG 3970
      VERT=SCS2(34)/2.8316846592E-02                                    OUTENG 3980
      VLDHDW=SCS2(35)/2.8316846592E-02                                  OUTENG 3990
      VLDS=SCS2(36)/2.8316846592E-02                                    OUTENG 4000
      VLRT=SCS2(37)/2.8316846592E-02                                    OUTENG 4010
      VOPT=SCS2(38)/2.8316846592E-02                                    OUTENG 4020
      VPRHDW=SCS2(39)/2.8316846592E-02                                  OUTENG 4030
      VPRS=SCS2(40)/2.8316846592E-02                                    OUTENG 4040
      VSUBD=SCS2(41)/2.8316846592E-02                                   OUTENG 4050
      VSUPD=SCS2(42)/2.8316846592E-02                                   OUTENG 4060
      VSYSTM=SCS2(43)/2.8316846592E-02                                  OUTENG 4070
      VTOTAL=SCS2(44)/2.8316846592E-02                                  OUTENG 4080
      WBASE=SCS2(45)/2.54E-02                                           OUTENG 4090
      WBXDEV=SCS2(46)/2.54E-02                                          OUTENG 4100
      WPP3=SCS1*1.0E+03                                                 OUTENG 4110
      XLP=SCS2(47)/1.0E+03                                              OUTENG 4120
C                                                                       OUTENG 4130
C                                                                       OUTENG 4140
      WRITE(30,501)                                                     OUTENG 4150
      IF(EJECT.NE.CAE.AND.EJECT.NE.SSE) WRITE(30,502)NBANK,RTIME,WPP3   OUTENG 4160
      IF(EJECT.EQ.CAE.OR.EJECT.EQ.SSE) WRITE(30,503)EREACT,NBANK,NEJECT,OUTENG 4170
     -RTIME,WPP3                                                        OUTENG 4180
      WRITE(30,504)((STMODE(I,J),J=1,6),I=1,10),(STMODE(I,1),           OUTENG 4190
     -(STMODE(I,J),J=7,10),I=1,10)                                      OUTENG 4200
      WRITE(30,505)XLP                                                  OUTENG 4210
      WRITE(30,506)MINJ,MCB,MBASE,VCOMB,MCAV,VCAV,MAW,VAW,MCS,VCS,MOPT, OUTENG 4220
     -VOPT,MDS,MLRREG,MLLINE,MLDHDW,VLDHDW,MLRT,VLRT,MLDS,VLDS          OUTENG 4230
      IF(EJECT.EQ.NO) GO TO 113                                         OUTENG 4240
      IF(EJECT.EQ.CAE) GO TO 110                                        OUTENG 4250
      IF(EJECT.EQ.SSE) GO TO 111                                        OUTENG 4260
      WRITE(30,507)MSUPD,VSUPD,MSUBD,VSUBD,MPRS,VPRS                    OUTENG 4270
      GO TO 112                                                         OUTENG 4280
110   WRITE(30,508)MSUPD,VSUPD,MSUBD,VSUBD,MEJECT,VEJECT,MERREG,MELINE, OUTENG 4290
     -MPRHDW,VPRHDW,MERT,VERT,MPRS,VPRS                                 OUTENG 4300
      GO TO 112                                                         OUTENG 4310
111   WRITE(30,509)MEJECT,VEJECT,MERREG,MELINE,MPRHDW,MERT,VERT,MPRS,   OUTENG 4320
     -VPRS                                                              OUTENG 4330
112   WRITE(30,510)MLDS,VLDS,MPRS,VPRS,MMISC,MTOTAL,VTOTAL,VSYSTM,WBASE,OUTENG 4340
     -LLDS,LPRS,LBXDEV,WBXDEV,HBXDEV,VBXDEV                             OUTENG 4350
      RETURN                                                            OUTENG 4360
113   WRITE(30,511)MLDS,VLDS,MMISC,MTOTAL,VTOTAL,VSYSTM,WBASE,LLDS,     OUTENG 4370
     -LBXDEV,WBXDEV,HBXDEV,VBXDEV                                       OUTENG 4380
C                                                                       OUTENG 4390
C                                                                       OUTENG 4400
C***********************************************************************OUTENG 4410
C*                                                                     *OUTENG 4420
C*                          FORMAT STATEMENTS                          *OUTENG 4430
C*                                                                     *OUTENG 4440
C***********************************************************************OUTENG 4450
C                                                                       OUTENG 4460
C                                                                       OUTENG 4470
201   FORMAT(*1*,///////,T47,*CHEMICAL LASER ANALYSIS PROGRAM (CLAP)*,//OUTENG 4480
     -,T53,*WRITTEN BY: C.L. ADAMS*,/,T65,*A.L. ADDY*,/,T65,*R.D. MASSEYOUTENG 4490
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     -*,/,T65,*C.D. MIKKELSFN*,/,T65,*G.F. MORR*,/,T65,*R.L. OGLUKIAN*,/OUTENG 4500
     -,T65,*R.J. WALKER*,//,T60,*1 JANUARY 77*,//,T51,*AFRODYNAMICS GROUOUTENG 4510
     -P (DRDMI-TDK)*,/,T51,*SYSTEM SIMULATION DIRECTORATF*,/,T42,*U.S. AOUTENG 4520
     -RMY MISSILE RESEARCH & DEVELOPMENT COMMAND*,/,T51,*REDSTONE ARSENAOUTENG 4530
     -L, ALARAMA 35809*,//,T57,*RUN DATF *,A10)                        OUTENG 4540
202   FORMAT(*0*,///,T52,*COMBUSTION CHEMISTRY SECTION*,//,T60,        OUTENG 4550
     -*INITIAL DATA:*,//,                                               OUTENG 4560
     -T31,*AEXP    =*,E13.6,* IN2*,T67,*ALPHA   =*,E13.6,/,             OUTENG 4570
     -T31,*DFORHF  =*,A13,T67,*N1      =*,I13,* ATOMS C*,/,             OUTENG 4580
     -T31,*N2      =*,I13,* ATOMS H*,T67,*N3      =*,I13,* ATOMS N*,/,  OUTENG 4590
     -T31,*N4      =*,I13,* ATOMS F*,T67,*WPG     =*,E13.6,* GM/S N2*,/,OUTENG 4600
     -T31,*WPR1    =*,E13.6,* GM/S C*,I1,*H*,I1,                        OUTENG 4610
     -T67,*WPR2    =*,E13.6,* GM/S HE*,/,T31,*WPR3    =*,E13.6,         OUTENG 4620
     -* GM/S N2*,T67,*WPR4    =*,E13.6,* GM/S N*,I1,*F*,I1,/,T31,       OUTENG 4630
     -*WSR1    =*,E13.6,* GM/S D2*,T67,*WSR2    =*,E13.6,* GM/S HE*,/,  OUTENG 4640
     -T31,*WSR3    =*,E13.6,* GM/S N2*)                                 OUTENG 4650
203   FORMAT(*0*,/////,T52,*COMRUSTION CHEMISTRY SECTION*,//,T60,      OUTENG 4660
     -*INITIAL DATA:*,//,                                               OUTENG 4670
     -T31,*AEXP    =*,E13.6,* IN2*,T67,*ALPHA   =*,E13.6,/,             OUTENG 4680
     -T31,*DFORHF  =*,A13,T67,*N1      =*,I13,* ATOMS C*,/,             OUTENG 4690
     -T31,*N2      =*,I13,* ATOMS D*,T67,*N3      =*,I13,* ATOMS N*,/,  OUTENG 4700
     -T31,*N4      =*,I13,* ATOMS F*,T67,*WPG     =*,E13.6,* GM/S N2*,/,OUTENG 4710
     -T31,*WPR1    =*,E13.6,* GM/S C*,I1,*D*,I1,                        OUTENG 4720
     -T67,*WPR2    =*,E13.6,* GM/S HE*,/,T31,*WPR3    =*,E13.6,         OUTENG 4730
     -* GM/S N2*,T67,*WPR4    =*,E13.6,* GM/S N*,I1,*F*,I1,/,T31,       OUTENG 4740
     -*WSR1    =*,E13.6,* GM/S H2*,T67,*WSR2    =*,E13.6,* GM/S HE*,/,  OUTENG 4750
     -T31,*WSR3    =*,E13.6,* GM/S N2*)                                 OUTENG 4760
204   FORMAT(*0*,T59,*RESULTANT DATA:*,//,                             OUTENG 4770
     -T31,*FDAA    =*,E13.6,* GMOLE/S-IN2*,T67,*OMEGA   =*,E13.6,/,     OUTENG 4780
     -T31,*OMEGTRW =*,E13.6,T67,*PSIC    =*,E13.6,/,                    OUTENG 4790
     -T31,*PSIL    =*,E13.6,T67,*PSILTRW =*,E13.6,/,                    OUTENG 4800
     -T31,*Q       =*,E13.6,* CAL/GMOLE*,T67,*RC      =*,E13.6,/,       OUTENG 4810
     -T31,*RL      =*,E13.6,T67,*RLF     =*,E13.6)                      OUTENG 4820
205   FORMAT(*0*,                                                      OUTENG 4830
     -T31,*WFCP1   =*,E13.6,* CF4*,T67,*XFCP1   =*,E13.6,* CF4*,/,      OUTENG 4840
     -T31,*WFCP2   =*,E13.6,* HF*,T67,*XFCP2   =*,E13.6,* HF*,/,        OUTENG 4850
     -T31,*WFCP3   =*,E13.6,* DF*,T67,*XFCP3   =*,E13.6,* DF*,/,        OUTENG 4860
     -T31,*WFCP4   =*,E13.6,* HE*,T67,*XFCP4   =*,E13.6,* HE*,/,        OUTENG 4870
     -T31,*WFCP5   =*,E13.6,* N2*,T67,*XFCP5   =*,E13.6,* N2*,/,        OUTENG 4880
     -T31,*WFCP6   =*,E13.6,* D*,T67,*XFCP6   =*,E13.6,* D*)            OUTENG 4890
206   FORMAT(*0*,                                                      OUTENG 4900
     -T31,*WFCP1   =*,E13.6,* CF4*,T67,*XFCP1   =*,E13.6,* CF4*,/,      OUTENG 4910
     -T31,*WFCP2   =*,E13.6,* HF*,T67,*XFCP2   =*,E13.6,* HF*,/,        OUTENG 4920
     -T31,*WFCP3   =*,E13.6,* DF*,T67,*XFCP3   =*,E13.6,* DF*,/,        OUTENG 4930
     -T31,*WFCP4   =*,E13.6,* HE*,T67,*XFCP4   =*,E13.6,* HE*,/,        OUTENG 4940
     -T31,*WFCP5   =*,E13.6,* N2*,T67,*XFCP5   =*,E13.6,* N2*,/,        OUTENG 4950
     -T31,*WFCP6   =*,E13.6,* H*,T67,*XFCP6   =*,E13.6,* H*)            OUTENG 4960
301   FORMAT(*1*,T56,*LASER DEVICE SECTION*,//,T60,*INITIAL DATA:*)    OUTENG 4970
302   FORMAT(*0*,T31,*BRFRAC  =*,E13.6,T67,*CANGLE  =*,E13.6,* DEG*,/, OUTENG 4980
     -T31,*D1      =*,E13.6,* IN*,T67,*D1S     =*,E13.6,* IN*,/,        OUTENG 4990
     -T31,*D3      =*,E13.6,* IN*,T67,*D3S     =*,E13.6,* IN*,/,        OUTENG 5000
     -T31,*GEOMPN  =*,A13,T67,*GEOMSN  =*,A13,/,                        OUTENG 5010
     -T31,*HBASE   =*,E13.6,* IN*,T67,*HNB     =*,E13.6,* IN*,/,        OUTENG 5020
     -T31,*LCAV    =*,E13.6,* IN*,T67,*LPNOZ   =*,E13.6,* IN*,/,        OUTENG 5030
     -T31,*LSNOZ   =*,E13.6,* IN*,T67,*NSPNOZ  =*,E13.6,/,              OUTENG 5040
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     -T31,*PKFRAC  =*,E13.6,T67,*P10      =*,E13.6,* PSIA*,/,              OUTENG 5050
     -T31,*T30     =*,E13.6,* K*,T67,*T70      =*,E13.6,* K*)              OUTENG 5060
 303  FORMAT(*0*,T31,*RRFRAC  =*,E13.6,T67,*CANGLF  =*,E13.6,* DEG*,/,     OUTENG 5070
     -T31,*D1      =*,E13.6,* IN*,T67,*D1S      =*,E13.6,* IN*,/,          OUTENG 5080
     -T31,*D3      =*,E13.6,* IN*,T67,*D3S      =*,E13.6,* IN*,/,          OUTENG 5090
     -T31,*GEOMPN  =*,A13,T67,*GEOMSN  =*,A13,/,                           OUTENG 5100
     -T31,*HBASE   =*,E13.6,* IN*,T67,*HNR      =*,E13.6,* IN*,/,          OUTENG 5110
     -T31,*LCAV    =*,E13.6,* IN*,T67,*LPNOZ    =*,E13.6,* IN*,/,          OUTENG 5120
     -T31,*LSNOZ   =*,E13.6,* IN*,T67,*NSPNOZ   =*,E13.6,/,                OUTENG 5130
     -T31,*PKFRAC  =*,E13.6,T67,*T10      =*,E13.6,* K*,/,                 OUTENG 5140
     -T31,*T30     =*,E13.6,* K*,T67,*T70      =*,E13.6,* K*)              OUTENG 5150
 304  FORMAT(*0*,T59,*RESULTANT DATA:*,//,T22,*POINT 1  PRIMARY NOZZLE EOUTENG 5160
     -XIT - CONDITIONS BASED ON THE NOZZLE STAGNATION*,/,T31,*(COMBUSTOROUTENG 5170
     -) TEMPERATURE*,//,                                                   OUTENG 5180
     -T31,*A1      =*,E13.6,* S-IN2/LBMOLE*,T67,*A1A1SE  =*,E13.6,/,       OUTENG 5190
     -T31,*A1A1SG  =*,E13.6,T67,*B1       =*,E13.6,/,                      OUTENG 5200
     -T31,*MW1     =*,E13.6,* LBM/LBMOLE*,T67,*M1       =*,E13.6,/,        OUTENG 5210
     -T31,*NPNOZ   =*,E13.6,* S/LBMOLE*,T67,*P1       =*,E13.6,* TORR*,/,OUTENG 5220
     -T31,*P10     =*,E13.6,* PSIA*,T67,*RE1      =*,E13.6,/,              OUTENG 5230
     -T31,*R1      =*,E13.6,* GM/CM3*,T67,*R10      =*,E13.6,* GM/CM3*,/,OUTENG 5240
     -T31,*T1      =*,E13.6,* K*,T67,*T10      =*,E13.6,* K*)              OUTENG 5250
 305  FORMAT(*0*,T22,*POINT 2  PRIMARY NOZZLE EXIT - CONDITIONS BASED ONOUTENG 5260
     - THE NOZZLE EXIT*,/,T31,*TEMPERATURE*,//,                            OUTENG 5270
     -T31,*A2      =*,E13.6,* S-IN2/LBMOLE*,T67,*B2       =*,E13.6,/,      OUTENG 5280
     -T31,*MW2     =*,E13.6,* LBM/LBMOLE*,T67,*M2       =*,E13.6,/,        OUTENG 5290
     -T31,*P2      =*,E13.6,* TORR*,T67,*P20      =*,E13.6,* PSIA*,/,      OUTENG 5300
     -T31,*R2      =*,E13.6,* GM/CM3*,T67,*R2       =*,E13.6,* GM/CM3*,/,OUTENG 5310
     -T31,*T2      =*,E13.6,* K*,T67,*T20      =*,E13.6,* K*)              OUTENG 5320
 306  FORMAT(*0*,T22,*POINT 3  SECONDARY NOZZLE EXIT - CONDITIONS BASED OUTENG 5330
     -ON THE NOZZLE STAGNATION*,/,T31,*(COMBUSTOR) TEMPERATURE*,//,        OUTENG 5340
     -T31,*A3      =*,E13.6,* S-IN2/LBMOLE*,T67,*A3A3SE  =*,E13.6,/,       OUTENG 5350
     -T31,*A3A3SG  =*,E13.6,T67,*B3       =*,E13.6,/,                      OUTENG 5360
     -T31,*MW3     =*,E13.6,* LBM/LBMOLE*,T67,*M3       =*,E13.6,/,        OUTENG 5370
     -T31,*NSNOZ3  =*,E13.6,* S/LBMOLE*,T67,*P3       =*,E13.6,* TORR*,/,OUTENG 5380
     -T31,*P30     =*,E13.6,* PSIA*,T67,*RE3      =*,E13.6,/,              OUTENG 5390
     -T31,*R3      =*,E13.6,* GM/CM3*,T67,*R30      =*,E13.6,* GM/CM3*,/,OUTENG 5400
     -T31,*T3      =*,E13.6,* K*,T67,*T30      =*,E13.6,* K*,/,            OUTENG 5410
     -T31,*W3W1    =*,E13.6,T67,*X3X1    =*,E13.6)                         OUTENG 5420
 307  FORMAT(*0*,T22,*POINT 4  SECONDARY NOZZLE EXIT - CONDITIONS BASED OUTENG 5430
     -ON THE NOZZLE EXIT*,/,T31,*TEMPERATURE*,//,                          OUTENG 5440
     -T31,*A4      =*,E13.6,* S-IN2/LBMOLE*,T67,*B4       =*,E13.6,/,      OUTENG 5450
     -T31,*MW4     =*,E13.6,* LBM/LBMOLE*,T67,*M4       =*,E13.6,/,        OUTENG 5460
     -T31,*P4      =*,E13.6,* TORR*,T67,*P40      =*,E13.6,* PSIA*,/,      OUTENG 5470
     -T31,*R4      =*,E13.6,* GM/CM3*,T67,*R40      =*,E13.6,* GM/CM3*,/,OUTENG 5480
     -T31,*T4      =*,E13.6,* K*,T67,*T40      =*,E13.6,* K*,/,            OUTENG 5490
     -T31,*W4W2    =*,E13.6,T67,*X4X2    =*,E13.6)                         OUTENG 5500
 308  FORMAT(*0*,T22,*POINT 5  CONSTANT-AREA MIXING REGION EXIT*,//,       OUTENG 5510
     -T31,*A5      =*,E13.6,* S-IN2/LBMOLE*,T67,*B5       =*,E13.6,/,      OUTENG 5520
     -T31,*MW5     =*,E13.6,* LBM/LBMOLE*,T67,*M5       =*,E13.6,/,        OUTENG 5530
     -T31,*P5      =*,E13.6,* TORR*,T67,*P50      =*,E13.6,* TORR*,/,      OUTENG 5540
     -T31,*R5      =*,E13.6,* GM/CM3*,T67,*R50      =*,E13.6,* GM/CM3*,/,OUTENG 5550
     -T31,*T5      =*,E13.6,* K*,T67,*T50      =*,E13.6,* K*,/,            OUTENG 5560
     -T31,*W5W2    =*,E13.6,T67,*X5X2    =*,E13.6)                         OUTENG 5570
 309  FORMAT(*0*,T22,*POINT 6  ISENTROPIC EXPANSION REGION EXIT*,//,       OUTENG 5580
     -T31,*A6      =*,E13.6,* S-IN2/LBMOLE*,T67,*B6       =*,E13.6,/,      OUTENG 5590
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     -T31,*MW6      =*,E13.6,* LBM/LBMOLE*,T67,*M6       =*,E13.6,/,     OUTENG 5600
     -T31,*P6       =*,E13.6,* TORR*,T67,*P60      =*,E13.6,* TORR*,/,   OUTENG 5610
     -T31,*R6       =*,E13.6,* GM/CM3*,T67,*R60     =*,E13.6,* GM/CM3*,/,OUTENG 5620
     -T31,*T6       =*,E13.6,* K*,T67,*T60      =*,F13.6,* K*,/,         OUTENG 5630
     -T31,*W6W2     =*,E13.6,T67,*X6X2     =*,E13.6)                     OUTENG 5640
310   FORMAT(*0*,T22,*POINT 7  MIRROR PURGE CONDITIONS*,//,              OUTENG 5650
     -T31,*G7       =*,E13.6,T67,*MW7      =*,E13.6,* LBM/LBMOLE*,/,     OUTENG 5660
     -T31,*T70      =*,E13.6,* K*,T67,*W7W2     =*,F13.6,/,              OUTENG 5670
     -T31,*X7X2     =*,E13.6)                                            OUTENG 5680
311   FORMAT(*0*,T22,*POINT 8  LASER CAVITY EXIT*,//,                    OUTENG 5690
     -T31,*A8       =*,E13.6,* S-IN2/LBMOLE*,T67,*G8        =*,E13.6,/,  OUTENG 5700
     -T31,*MW8      =*,E13.6,* LBM/LBMOLE*,T67,*M8       =*,E13.6,/,     OUTENG 5710
     -T31,*P8       =*,E13.6,* TORR*,T67,*P80      =*,E13.6,* TORR*,/,   OUTENG 5720
     -T31,*RE8      =*,E13.6,T67,*R8        =*,E13.6,* GM/CM3*,/,        OUTENG 5730
     -T31,*R80      =*,E13.6,* GM/CM3*,T67,*T8       =*,E13.6,* K*,/,    OUTENG 5740
     -T31,*T80      =*,E13.6,* K*,T67,*W8W2     =*,F13.6,/,              OUTENG 5750
     -T31,*X8X2     =*,E13.6)                                            OUTENG 5760
312   FORMAT(*0*,T22,*WARNING: THE CAVITY FLOW HAS SEPARATED.  ALL FURTHOUTENG 5770
     -ER RESULTS SHOULD BE USED*,/,T31,*WITH CAUTION.*)                  OUTENG 5780
313   FORMAT(*0*,T22,*POINT 8  LASER CAVITY EXIT*,//,                    OUTENG 5790
     -T31,*A8       =*,E13.6,* S-IN2/LBMOLE*,T67,*G8        =*,E13.6,/,  OUTENG 5800
     -T31,*LSEP     =*,E13.6,* IN*,T67,*MW8      =*,E13.6,* LBM/LBMOLE*,/,OUTENG 5810
     -T31,*M8       =*,E13.6,T67,*P8       =*,E13.6,* TORR*,/,           OUTENG 5820
     -T31,*P80      =*,E13.6,* TORR*,T67,*RE8      =*,E13.6,/,           OUTENG 5830
     -T31,*R8       =*,E13.6,* GM/CM3*,T67,*R80     =*,E13.6,* GM/CM3*,/,OUTENG 5840
     -T31,*T8       =*,E13.6,* K*,T67,*T80      =*,F13.6,* K*,/,         OUTENG 5850
     -T31,*W8W2     =*,E13.6,T67,*X8X2     =*,E13.6)                     OUTENG 5860
314   FORMAT(*0*,T22,*WARNING: THE CAVITY FLOW HAS CHOKED.  ALL FURTHER OUTENG 5870
     -CALCULATIONS HAVE*,/,T31,*BEEN DISCONTINUED*)                      OUTENG 5880
401   FORMAT(*1*,T54,*PRESSURE RECOVERY SECTION* //,T60,*INITIAL DATA:*)OUTENG 5890
402   FORMAT(*0*,T31,*A3A2      =*,E13.6,T67,*EJECT     =*,A13,/,        OUTENG 5900
     -T31,*ETA12    =*,E13.6)                                            OUTENG 5910
403   FORMAT(*0*,T31,*A3A2      =*,E13.6,T67,*A7A6      =*,E13.6,/,      OUTENG 5920
     -T31,*EJECT    =*,A13,T67,*ETA12    =*,E13.6,/,                     OUTENG 5930
     -T31,*G5       =*,E13.6,T67,*MW5      =*,E13.6,* LBM/LBMOLE*,/,     OUTENG 5940
     -T31,*P50      =*,E13.6,* PSIA*,T67,*P7       =*,E13.6,* TORR*,/,   OUTENG 5950
     -T31,*T50      =*,E13.6,* K*)                                       OUTENG 5960
404   FORMAT(*0*,T31,*A7A6      =*,E13.6,T67,*EJECT     =*,A13,/,        OUTENG 5970
     -T31,*G5       =*,E13.6,T67,*LIMIT     =*,A13,/,                    OUTENG 5980
     -T31,*MW5      =*,E13.6,* LBM/LBMOLE*,T67,*P50      =*,E13.6,* PSIA*,OUTENG 5990
     -/,T31,*P7      =*,E13.6,* TORR*,T67,*T50      =*,E13.6,* K*)       OUTENG 6000
405   FORMAT(*0*,T59,*RESULTANT DATA:*,//,T22,*POINT 1  LASER CAVITY EXIOUTENG 6010
     -T AND NORMAL SHOCK DIFFUSER ENTRANCE*)                             OUTENG 6020
406   FORMAT(*0*,T59,*RESULTANT DATA:*,//,T22,*POINT 1  LASER CAVITY EXIOUTENG 6030
     -T AND CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR*,/,T31,*SECONDAOUTENG 6040
     -RY ENTRANCE*)                                                      OUTENG 6050
407   FORMAT(*0*,                                                        OUTENG 6060
     -T31,*A1       =*,E13.6,* S-IN2/LBMOLE*,T67,*G1        =*,E13.6,/,  OUTENG 6070
     -T31,*MW1      =*,E13.6,* LBM/LBMOLE*,T67,*M1       =*,E13.6,/,     OUTENG 6080
     -T31,*P1       =*,E13.6,* TORR*,T67,*P10      =*,E13.6,* TORR*,/,   OUTENG 6090
     -T31,*R1       =*,E13.6,* GM/CM3*,T67,*R10     =*,E13.6,* GM/CM3*,/,OUTENG 6100
     -T31,*T1       =*,E13.6,* K*,T67,*T10      =*,F13.6,* K*)           OUTENG 6110
408   FORMAT(*0*,T22,*POINT 2  NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DOUTENG 6120
     -IFFUSER ENTRANCE*,//,                                              OUTENG 6130
     -T31,*A2       =*,E13.6,* S-IN2/LBMOLE*,T67,*ETA12   =*,E13.6,/,    OUTENG 6140
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     -T31,*G2       =*,E13.6,T67,*MW2     =*,E13.6,* LBM/LBMOLE*,/,      OUTENG 6150
     -T31,*M2       =*,E13.6,T67,*P2      =*,E13.6,* TORR*,/,            OUTENG 6160
     -T31,*P20      =*,E13.6,* TORR*,T67,*R2       =*,E13.6,* GM/CM3*,/, OUTENG 6170
     -T31,*R20      =*,F13.6,* GM/CM3*,T67,*T2       =*,E13.6,* K*,/,    OUTENG 6180
     -T31,*T20      =*,F13.6,* K*,T67,*W2W1     =*,F13.6,/,              OUTENG 6190
     -T31,*X2X1     =*,E13.6)                                            OUTENG 6200
409   FORMAT(*0*,T22,*POINT 3  SUBSONIC DIFFUSER EXIT *)                 OUTENG 6210
410   FORMAT(*+*,T55,*AND SUDDEN ENLARGEMENT ENTRANCE*)                  OUTENG 6220
411   FORMAT(*0*,                                                        OUTENG 6230
     -T31,*A3       =*,E13.6,* S-IN2/LBMOLE*,T67,*ETA23   =*,E13.6,/,    OUTENG 6240
     -T31,*G3       =*,E13.6,T67,*MW3     =*,E13.6,* LBM/LBMOLE*,/,      OUTENG 6250
     -T31,*M3       =*,E13.6,T67,*P3      =*,E13.6,* TORR*,/,            OUTENG 6260
     -T31,*P30      =*,E13.6,* TORR*,T67,*R3       =*,E13.6,* GM/CM3*,/, OUTENG 6270
     -T31,*R30      =*,F13.6,* GM/CM3*,T67,*T3       =*,E13.6,* K*,/,    OUTENG 6280
     -T31,*T30      =*,E13.6,* K*,T67,*W3W1     =*,E13.6,/,              OUTENG 6290
     -T31,*X3X1     =*,E13.6)                                            OUTENG 6300
412   FORMAT(*0*,T22,*POINT 4  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOOUTENG 6310
     -R SECONDARY NOZZLE EXIT*,//,                                       OUTENG 6320
     -T31,*A4       =*,E13.6,* S-IN2/LBMOLE*,T67,*G4       =*,E13.6,/,   OUTENG 6330
     -T31,*MW4      =*,E13.6,* LBM/LBMOLE*,T67,*M4       =*,E13.6,/,     OUTENG 6340
     -T31,*P4       =*,E13.6,* TORR*,T67,*P40      =*,E13.6,* TORR*,/,   OUTENG 6350
     -T31,*R4       =*,E13.6,* GM/CM3*,T67,*R40      =*,E13.6,* GM/CM3*,/,OUTENG 6360
     -T31,*T4       =*,F13.6,* K*,T67,*T40      =*,E13.6,* K*,/,         OUTENG 6370
     -T31,*W4W1     =*,E13.6,T67,*X4X1     =*,E13.6)                     OUTENG 6380
413   FORMAT(*0*,T22,*POINT 5  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOOUTENG 6390
     -R PRIMARY NOZZLE EXIT*)                                            OUTENG 6400
414   FORMAT(*0*,T22,*NOTE:    THE UPPER LIMIT POINT WAS USED AS THE LIMOUTENG 6410
     -ITING CONDITION FOR*,/,T31,*THE CONSTANT-AREA, SUPERSONIC-SUPERSONOUTENG 6420
     -IC EJECTOR*)                                                       OUTENG 6430
415   FORMAT(*0*,T22,*NOTE:    THE ZUKOSKI SEPARATION POINT WAS USED AS OUTENG 6440
     -THE LIMITING CONDITION FOR*,/,T31,*THE CONSTANT-AREA, SUPERSONIC-SOUTENG 6450
     -UPERSONIC EJECTOR*)                                                OUTENG 6460
416   FORMAT(*0*,T22,*NOTE:    THE MATCHED PRESSURE POINT WAS USED AS THOUTENG 6470
     -E LIMITING CONDITION FOR*,/,T31,*THE CONSTANT-AREA, SUPERSONIC-SUPOUTENG 6480
     -ERSONIC EJECTOR*)                                                  OUTENG 6490
417   FORMAT(*0*,T22,*POINT 5  CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECOUTENG 6500
     -TOR PRIMARY NOZZLE EXIT*)                                          OUTENG 6510
418   FORMAT(*0*,                                                        OUTENG 6520
     -T31,*A5       =*,E13.6,* S-IN2/LBMOLE*,T67,*G5       =*,E13.6,/,   OUTENG 6530
     -T31,*MW5      =*,E13.6,* LBM/LBMOLE*,T67,*M5       =*,E13.6,/,     OUTENG 6540
     -T31,*P5       =*,E13.6,* TORR*,T67,*P50      =*,E13.6,* PSIA*,/,   OUTENG 6550
     -T31,*R5       =*,E13.6,* GM/CM3*,T67,*R50      =*,E13.6,* GM/CM3*,/,OUTENG 6560
     -T31,*T5       =*,E13.6,* K*,T67,*T50      =*,F13.6,* K*,/,         OUTENG 6570
     -T31,*W5W1     =*,E13.6,T67,*X5X1     =*,E13.6)                     OUTENG 6580
419   FORMAT(*1*,T22,*POINT 6  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOOUTENG 6590
     -R EXIT AND SUBSONIC*,/,T31,*DIFFUSER ENTRANCE*)                    OUTENG 6600
420   FORMAT(*0*,T22,*POINT 6  CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECOUTENG 6610
     -TOR EXIT AND SUBSONIC*,/,T31,*DIFFUSER ENTRANCE*)                  OUTENG 6620
421   FORMAT(*0*,                                                        OUTENG 6630
     -T31,*A6       =*,E13.6,* S-IN2/LBMOLE*,T67,*G6       =*,E13.6,/,   OUTENG 6640
     -T31,*MW6      =*,F13.6,* LBM/LBMOLE*,T67,*M6       =*,E13.6,/,     OUTENG 6650
     -T31,*P6       =*,E13.6,* TORR*,T67,*P60      =*,E13.6,* TORR*,/,   OUTENG 6660
     -T31,*R6       =*,E13.6,* GM/CM3*,T67,*R60      =*,E13.6,* GM/CM3*,/,OUTENG 6670
     -T31,*T6       =*,E13.6,* K*,T67,*T60      =*,F13.6,* K*,/,         OUTENG 6680
     -T31,*W6W1     =*,E13.6,T67,*X6X1     =*,E13.6)                     OUTENG 6690
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422   FORMAT(*0*,T22,*POINT 7  SUBSONIC DIFFUSER EXIT*,//,                 OUTENG 6700
     -T31,*A7          =*,E13.6,* S-IN2/LBMOLE*,T67,*FTA67    =*,E13.6,/,  OUTENG 6710
     -T31,*G7          =*,E13.6,T67,*MW7      =*,E13.6,* LBM/LBMOLE*,/,    OUTENG 6720
     -T31,*M7          =*,E13.6,T67,*P7       =*,E13.6,* TORR*,/,          OUTENG 6730
     -T31,*P70         =*,E13.6,* TORR*,T67,*R7        =*,E13.6,* GM/CM3*,/, OUTENG 6740
     -T31,*R70         =*,E13.6,* GM/CM3*,T67,*T7        =*,E13.6,* K*,/,  OUTENG 6750
     -T31,*T70         =*,E13.6,* K*,T67,*W7W1     =*,E13.6,/,             OUTENG 6760
     -T31,*X7X1        =*,E13.6)                                           OUTENG 6770
501   FORMAT(*1*,T53,*SYSTEM CALCULATION SECTION*,//,T60,*INITIAL DATA:*OUTENG 6780
     -)                                                                    OUTENG 6790
502   FORMAT(*0*,T31,*NBANK     =*,I13,T67,*RTIME     =*,E13.6,* S*,/,     OUTENG 6800
     -T31,*WPP3        =*,E13.6,* KG/S*)                                   OUTENG 6810
503   FORMAT(*0*,T31,*FREACT    =*,A13,T67,*NBANK     =*,I13,/,            OUTENG 6820
     -T31,*NEJECT      =*,I13,T67,*RTIME     =*,E13.6,* S*,/,              OUTENG 6830
     -T31,*WPP3        =*,E13.6,* GM/S*)                                   OUTENG 6840
504   FORMAT(*0*,T55,*REACTANT STORAGE METHOD*,//,10(T31,6A11,/),          OUTENG 6850
     -10(/,T31,5A11))                                                      OUTENG 6860
505   FORMAT(*0*,T59,*RESULTANT DATA:*,//,T55,*SYSTEM SCALE-UP FACTOR*,    OUTENG 6870
     -//,T31,*XLP      =*,E13.6,* GMOLE/S*)                                OUTENG 6880
506   FORMAT(*0*,T51,*LASER DEVICE SYSTEM VOLUME/MASS*,//,                 OUTENG 6890
     -T31,*MINJ      =*,E13.6,* LBM*,/,T31,*MCB       =*,E13.6,* LBM*,/,   OUTENG 6900
     -T31,*MBASE     =*,E13.6,* LBM*,T67,*VCOMB     =*,E13.6,* FT3*,/,     OUTENG 6910
     -T31,*MCAV      =*,E13.6,* LBM*,T67,*VCAV      =*,E13.6,* FT3*,/,     OUTENG 6920
     -T31,*MAW       =*,E13.6,* LBM*,T67,*VAW       =*,E13.6,* FT3*,/,     OUTENG 6930
     -T31,*MCS       =*,E13.6,* LBM*,T67,*VCS       =*,E13.6,* FT3*,/,     OUTENG 6940
     -T31,*MOPT      =*,E13.6,* LBM*,T67,*VOPT      =*,E13.6,* FT3*,/,     OUTENG 6950
     -T31,*MDS       =*,E13.6,* LBM*,/,T31,*MLBREG  =*,E13.6,* LBM*,/,     OUTENG 6960
     -T31,*MLLINE  =*,E13.6,* LBM*,/,T42,*____________*,                   OUTENG 6970
     -T78,*____________*,/,T31,*MLDHDW  =*,E13.6,* LBM*,                   OUTENG 6980
     -T67,*VLDHDW  =*,E13.6,* FT3*,/,T31,*MLRT      =*,E13.6,* LBM*,       OUTENG 6990
     -T67,*VLRT      =*,E13.6,* FT3*,/,T42,*____________*,                 OUTENG 7000
     -T78,*____________*,/,T31,*MLDS      =*,E13.6,* LBM*,                 OUTENG 7010
     -T67,*VLDS      =*,E13.6,* FT3*)                                      OUTENG 7020
507   FORMAT(*1*,T48,*PRESSURE RECOVERY SYSTEM VOLUME/MASS*,//,            OUTENG 7030
     -T31,*MSUPD     =*,E13.6,* LBM*,T67,*VSUPD     =*,E13.6,* FT3*,/,     OUTENG 7040
     -T31,*MSUBD     =*,E13.6,* LBM*,T67,*VSUBD     =*,E13.6,* FT3*,/,     OUTENG 7050
     -T42,*____________*,T78,*____________*,/,                             OUTENG 7060
     -T31,*MPRS      =*,E13.6,* LBM*,T67,*VPRS      =*,E13.6,* FT3*)       OUTENG 7070
508   FORMAT(*1*,T48,*PRESSURE RECOVERY SYSTEM VOLUME/MASS*,//,            OUTENG 7080
     -T31,*MSUPD     =*,E13.6,* LBM*,T67,*VSUPD     =*,E13.6,* FT3*,/,     OUTENG 7090
     -T31,*MSUBD     =*,E13.6,* LBM*,T67,*VSUBD     =*,E13.6,* FT3*,/,     OUTENG 7100
     -T31,*MEJECT  =*,E13.6,* LBM*,T67,*VEJECT  =*,E13.6,* FT3*,/,         OUTENG 7110
     -T31,*MERREG  =*,E13.6,* LBM*,/,T31,*MELINE  =*,E13.6,* LBM*,/,       OUTENG 7120
     -T42,*____________*,T78,*____________*,/,                             OUTENG 7130
     -T31,*MPRHDW  =*,E13.6,* LBM*,T67,*VPRHDW  =*,E13.6,* FT3*,/,         OUTENG 7140
     -T31,*MERT      =*,E13.6,* LBM*,T67,*VERT      =*,E13.6,* FT3*,/,     OUTENG 7150
     -T42,*____________*,T78,*____________*,/,                             OUTENG 7160
     -T31,*MPRS      =*,E13.6,* LBM*,T67,*VPRS      =*,E13.6,* FT3*)       OUTENG 7170
509   FORMAT(*1*,T48,*PRESSURE RECOVERY SYSTEM VOLUME/MASS*,//,            OUTENG 7180
     -T31,*MEJECT  =*,E13.6,* LBM*,T67,*VEJECT  =*,E13.6,* FT3*,/,         OUTENG 7190
     -T31,*MERREG  =*,E13.6,* LBM*,/,T31,*MELINE  =*,E13.6,* LBM*,/,       OUTENG 7200
     -T42,*____________*,/,T31,*MPRHDW  =*,E13.6,* LBM*,/,                 OUTENG 7210
     -T31,*MERT      =*,E13.6,* LBM*,T67,*VERT      =*,E13.6,* FT3*,/,     OUTENG 7220
     -T42,*____________*,T78,*____________*,/,                             OUTENG 7230
     -T31,*MPRS      =*,E13.6,* LBM*,T67,*VPRS      =*,E13.6,* FT3*)       OUTENG 7240
```

```
510   FORMAT(*0*,T53,*SYSTEM VOLUME/MASS SUMMARY*,//,                  OUTENG 7250
     -T31,*WLDS     =*,E13.6,* LBM*,T67,*VLDS     =*,E13.6,* FT3*,/,   OUTENG 7260
     -T31,*WPRS     =*,E13.6,* LBM*,T67,*VPRS     =*,E13.6,* FT3*,/,   OUTENG 7270
     -T31,*WMISC    =*,E13.6,* LBM*,/,T42,*_____________*,             OUTENG 7280
     -T78,*_____________*,/,T31,*WTOTAL   =*,E13.6,* LBM*,             OUTENG 7290
     -T67,*VTOTAL   =*,E13.6,* FT3*,/,T67,*VSYSTM   =*,E13.6,* FT3*,//, OUTENG 7300
     -T31,*WBASF    =*,E13.6,* IN*,T67,*LLDS     =*,E13.6,* IN*,/,     OUTENG 7310
     -T31,*LPRS     =*,E13.6,* IN*,//,T31,*LBXDEV   =*,E13.6,* IN*,    OUTENG 7320
     -T67,*WRXDEV   =*,E13.6,* IN*,/,T31,*HBXDEV   =*,E13.6,* IN*,     OUTENG 7330
     -T67,*VBXDEV   =*,E13.6,* FT3*)                                   OUTENG 7340
511   FORMAT(*1*,T53,*SYSTEM VOLUME/MASS SUMMARY*,//,                  OUTENG 7350
     -T31,*WLDS     =*,E13.6,* LBM*,T67,*VLDS     =*,E13.6,* FT3*,/,   OUTENG 7360
     -T31,*WMISC    =*,E13.6,* LBM*,/,T42,*_____________*,             OUTENG 7370
     -T78,*_____________*,/,T31,*WTOTAL   =*,E13.6,* LBM*,             OUTENG 7380
     -T67,*VTOTAL   =*,E13.6,* FT3*,/,T67,*VSYSTM   =*,E13.6,* FT3*,//, OUTENG 7390
     -T31,*WBASE    =*,E13.6,* IN*,T67,*LLDS     =*,E13.6,* IN*,//,    OUTENG 7400
     -T31,*LRXDEV   =*,E13.6,* IN*,T67,*WBXDEV   =*,E13.6,* IN*,/,     OUTENG 7410
     -T31,*HBXDEV   =*,E13.6,* IN*,T67,*VBXDEV   =*,E13.6,* FT3*)      OUTENG 7420
      END                                                              OUTENG 7430
```

Appendix B. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)–OVERLAY CCS

```
      OVERLAY(CCS,1,0)                                                 CCS      0100
      PROGRAM CCS                                                      CCS      0110
C                                                                      CCS      0120
C                                                                      CCS      0130
C**********************************************************************CCS      0140
C*                                                                    *CCS      0150
C*                  COMBUSTION CHEMISTRY OVERLAY (CCS)                *CCS      0160
C*                                                                    *CCS      0170
C**********************************************************************CCS      0180
C                                                                      CCS      0190
C**********************************************************************CCS      0200
C*                                                                    *CCS      0210
C*   OVERLAY CCS PERFORMS THE  COMBUSTION CHEMISTRY CALCULATIONS FOR  *CCS      0220
C*   PROGRAM CLAP.                                                    *CCS      0230
C*                                                                    *CCS      0240
C* INPUT VARIABLES:                                                   *CCS      0250
C*                                                                    *CCS      0260
C* AFXP    = NOZZLE BANK AREA OF THE EXPERIMENTAL DEVICE (M2)         *CCS      0270
C* ALPHA   = FLUORINE DISSOCIATION FRACTION                           *CCS      0280
C* CCSS1   = CONTROL VARIABLE                                         *CCS      0290
C* DFORHF  = CONTROL VARIABLE SUCH THAT:                              *CCS      0300
C*         = "DF" FOR A DF CHEMICAL LASER                             *CCS      0310
C*         = "HF" FOR A HF CHEMICAL LASER                             *CCS      0320
C* N1      = NUMBER OF CARBON ATOMS IN PRIMARY REACTANT 1             *CCS      0330
C* N2      = NUMBER OF HYDROGEN ATOMS IN PRIMARY REACTANT 1           *CCS      0340
C* N3      = NUMBER OF NITROGEN ATOMS IN PRIMARY REACTANT 4           *CCS      0350
C* N4      = NUMBER OF FLUORINE ATOMS IN PRIMARY REACTANT 4           *CCS      0360
C* WPG     = MASS FLOW RATE OF MIRROR PURGE N2 (KG/S)                 *CCS      0370
C* WPR1    = MASS FLOW RATE OF C-N1 H-N2 (KG/S)                       *CCS      0380
C* WPR2    = MASS FLOW RATE OF HE (KG/S)                              *CCS      0390
C* WPR3    = MASS FLOW RATE OF N2 (KG/S)                              *CCS      0400
C* WPR4    = MASS FLOW RATE OF N-N3 F-N4 (KG/S)                       *CCS      0410
C* WSR1    = MASS FLOW RATE OF D2 (KG/S)                              *CCS      0420
C* WSR2    = MASS FLOW RATE OF HE (KG/S)                              *CCS      0430
C* WSR3    = MASS FLOW RATE OF N2 (KG/S)                              *CCS      0440
C*                                                                    *CCS      0450
C* OUTPUT VARIABLES:                                                  *CCS      0460
C*                                                                    *CCS      0470
C* FDAA    = FREE FLUORINE FLUX (KMOLE/S-M2)                          *CCS      0480
C* OMEGA   = TOTAL LASER MOLAR DILUENT RATIO                          *CCS      0490
C* OMEGATRW = TOTAL LASER MOLAR DILUENT RATIO (TRW DEFINITION)        *CCS      0500
C* PSIC    = MOLAR COMBUSTOR DILUENT RATIO                            *CCS      0510
C* PSIL    = MOLAR CAVITY DILUENT RATIO                               *CCS      0520
C* PSILTRW = MOLAR CAVITY DILUENT RATIO (TRW DEFINITION)              *CCS      0530
C* Q       = HEAT RELEASED PER KMOLE OF PRIMARY FLOW BY THE CHEMICAL   *CCS      0540
C*           REACTION OF FLUORINE IN THE LASER CAVITY (J/KMOLE)       *CCS      0550
C* RC      = MOLAR COMBUSTOR MIXTURE RATIO                            *CCS      0560
C* RL      = MOLAR CAVITY MIXTURE RATIO                               *CCS      0570
C* RLF     = TOTAL LASER CAVITY MIXTURE RATIO                         *CCS      0580
C* WFCP1   = MASS FRACTION OF C[illegible]                            *CCS      0590
C* WFCP2   = MASS FRACTION OF HF                                      *CCS      0600
C* WFCP3   = MASS FRACTION OF DF                                      *CCS      0610
C* WFCP4   = MASS FRACTION OF HE                                      *CCS      0620
C* WFCP5   = MASS FRACTION OF N2                                      *CCS      0630
C* WFCP6   = MASS FRACTION OF F                                       *CCS      0640
```

```
C* WFPP3   = MASS FRACTION OF F                                         *CCS    0650
C* WFPR1   = MASS FRACTION OF C-N1 H-N2  (C-N1 D-N2)                    *CCS    0660
C* WFPR2   = MASS FRACTION OF HE                                        *CCS    0670
C* WFPR3   = MASS FRACTION OF N2                                        *CCS    0680
C* WFPR4   = MASS FRACTION OF N-N3 F-N4                                 *CCS    0690
C* WFSR1   = MASS FRACTION OF D2  (H2)                                  *CCS    0700
C* WFSR2   = MASS FRACTION OF HE                                        *CCS    0710
C* WFSR3   = MASS FRACTION OF N2                                        *CCS    0720
C* WPGWPP  = MIRROR PURGE-TO-PRIMARY COMBUSTOR PRODUCT MASS FLOW RATIO  *CCS    0730
C* XFCP1   = MOLE FRACTION OF CF4                                       *CCS    0740
C* XFCP2   = MOLE FRACTION OF HF                                        *CCS    0750
C* XFCP3   = MOLE FRACTION OF DF                                        *CCS    0760
C* XFCP4   = MOLE FRACTION OF HE                                        *CCS    0770
C* XFCP5   = MOLE FRACTION OF N2                                        *CCS    0780
C* XFCP6   = MOLE FRACTION OF D  (H)                                    *CCS    0790
C* XFPP1   = MOLE FRACTION OF CF4                                       *CCS    0800
C* XFPP2   = MOLE FRACTION OF F2                                        *CCS    0810
C* XFPP3   = MOLE FRACTION OF F                                         *CCS    0820
C* XFPP4   = MOLE FRACTION OF HF  (DF)                                  *CCS    0830
C* XFPP5   = MOLE FRACTION OF HE                                        *CCS    0840
C* XFPP6   = MOLE FRACTION OF N2                                        *CCS    0850
C* XFSR1   = MOLE FRACTION OF D2  (H2)                                  *CCS    0860
C* XFSR2   = MOLE FRACTION OF HE                                        *CCS    0870
C* XFSR3   = MOLE FRACTION OF N2                                        *CCS    0880
C*                                                                      *CCS    0890
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS.                    *CCS    0900
C*                                                                      *CCS    0910
C************************************************************************CCS    0920
C                                                                        CCS    0930
C************************************************************************CCS    0940
C*                                                                      *CCS    0950
C*                              NOTATION SCHEME                         *CCS    0960
C*                                                                      *CCS    0970
C* VARIABLES ARE DEFINED AS FOLLOWS :                                   *CCS    0980
C*                                                                      *CCS    0990
C* PREFIX:                                                              *CCS    1000
C*                                                                      *CCS    1010
C* W       = MASS FLOW RATE                                             *CCS    1020
C* WF      = MASS FRACTION                                              *CCS    1030
C* X       = MOLAR FLOW RATE                                            *CCS    1040
C* XF      = MOLE FRACTION                                              *CCS    1050
C*                                                                      *CCS    1060
C* SUFFIX:                                                              *CCS    1070
C*                                                                      *CCS    1080
C* CP      = CAVITY PRODUCT                                             *CCS    1090
C* PG      = MIRROR PURGE                                               *CCS    1100
C* PP      = PRIMARY COMBUSTOR PRODUCT                                  *CCS    1110
C* PR      = PRIMARY COMBUSTOR REACTANT                                 *CCS    1120
C* SR      = SECONDARY REACTANT                                         *CCS    1130
C*                                                                      *CCS    1140
C* EXAMPLE: XFPP1 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 1        *CCS    1150
C*                                                                      *CCS    1160
C* LASER PRIMARY COMBUSTOR REACTANTS:                                   *CCS    1170
C*                                                                      *CCS    1180
C* PR1     = C-N1 H-N2  (C-N1 D-N2)                                     *CCS    1190
```

```
C* PR2      = HF                                                       *CCS     1200
C* PR3      = N2                                                       *CCS     1210
C* PR4      = N-N3 F-N4                                                *CCS     1220
C*                                                                     *CCS     1230
C* LASER SECONDARY REACTANTS:                                          *CCS     1240
C*                                                                     *CCS     1250
C* SR1      = D2   (H2)                                                *CCS     1260
C* SR2      = HE                                                       *CCS     1270
C* SR3      = N2                                                       *CCS     1280
C*                                                                     *CCS     1290
C* LASER PRIMARY COMBUSTOR PRODUCTS:                                   *CCS     1300
C*                                                                     *CCS     1310
C* PP1      = CF4                                                      *CCS     1320
C* PP2      = F2                                                       *CCS     1330
C* PP3      = F                                                        *CCS     1340
C* PP4      = HF   (DF)                                                *CCS     1350
C* PP5      = HE                                                       *CCS     1360
C* PP6      = N2                                                       *CCS     1370
C*                                                                     *CCS     1380
C* LASER CAVITY PRODUCTS:                                              *CCS     1390
C*                                                                     *CCS     1400
C* CP1      = CF4                                                      *CCS     1410
C* CP2      = HF                                                       *CCS     1420
C* CP3      = DF                                                       *CCS     1430
C* CP4      = HE                                                       *CCS     1440
C* CP5      = N2                                                       *CCS     1450
C* CP6      = D    (H)                                                 *CCS     1460
C*                                                                     *CCS     1470
C**********************************************************************CCS     1480
C                                                                       CCS     1490
C                                                                       CCS     1500
      REAL NO                                                           CCS     1510
C                                                                       CCS     1520
      COMMON/CCS1/CCSS1                                                 CCS     1530
C                                                                       CCS     1540
      COMMON/CCS2/AEXP,ALPHA,WPG,WPR1,WPR2,WPR3,WPR4,WSR1,WSR2,WSR3     CCS     1550
C                                                                       CCS     1560
      COMMON/CCS3/DFORHF                                                CCS     1570
C                                                                       CCS     1580
      COMMON/CCS4/FDAA                                                  CCS     1590
C                                                                       CCS     1600
      COMMON/CCS5/N1,N2,N3,N4                                           CCS     1610
C                                                                       CCS     1620
      COMMON/CCS6/OMEGA,OMEGTRW,PSIC,PSIL,PSILTRW,RC,RLF,WFCP1,WFCP2,   CCS     1630
     -WFCP3,WFCP4,WFCP5,WFCP6                                           CCS     1640
C                                                                       CCS     1650
      COMMON/CCS7/Q                                                     CCS     1660
C                                                                       CCS     1670
      COMMON/CCS8/RL                                                    CCS     1680
C                                                                       CCS     1690
      COMMON/CCS9/WFPP3,WFPR1,WFPR4,WFSR1                               CCS     1700
C                                                                       CCS     1710
      COMMON/CCS10/WFPR2,WFPR3,WFSR2,WFSR3                              CCS     1720
C                                                                       CCS     1730
      COMMON/CCS11/WPGWPP                                               CCS     1740
```

```
C
      COMMON/CCS12/XFCP1(2),XFCP2(2),XFCP3(2),XFCP4(2),XFCP5(2),XFCP6(2)
C
      COMMON/CCS13/XFPP1,XFPP4,XFPP5,XFPP6
C
      COMMON/CCS14/XFPP2
C
      COMMON/CCS15/XFPP3
C
      COMMON/CCS16/XFSR1,XFSR2,XFSR3
C
      DATA D2F/1.29662E+08/,D2F2/5.51033E+08/,H2F/1.31294E+08/,
     -H2F2/5.45092E+08/
C
      DATA DF/2HDF/,HF/2HHF/,NO/2HNO/
C
C
C***********************************************************************
C*                                                                    *
C*                        READ INPUT DATA                             *
C*                                                                    *
C***********************************************************************
C
C
      CALL INCCS
      IF(CCSS1.EQ.NO) GO TO 103
C
C
C***********************************************************************
C*                                                                    *
C*    COMPUTE PRIMARY COMBUSTOR REACTANT MOLAR FLOW RATES (KMOLE/S)   *
C*                                                                    *
C***********************************************************************
C
C
      IF(DFORHF.EQ.DF) XPR1=WPR1/(N1*12.0111+N2*1.00797)
      IF(DFORHF.EQ.HF) XPR1=WPR1/(N1*12.0111+N2*2.01410)
      XPR2=WPR2/4.00260
      XPR3=WPR3/28.0134
      XPR4=WPR4/(N3*14.0067+N4*18.9984)
C
C
C***********************************************************************
C*                                                                    *
C*      COMPUTE MOLE FRACTIONS OF THE PRIMARY COMBUSTOR REACTANTS     *
C*                                                                    *
C***********************************************************************
C
C
      XPRTOT=XPR1+XPR2+XPR3+XPR4
      XFPR1=XPR1/XPRTOT
      XFPR2=XPR2/XPRTOT
      XFPR3=XPR3/XPRTOT
      XFPR4=XPR4/XPRTOT
C
```

```
C                                                                       CCS
C***********************************************************************CCS
C*                                                                     *CCS
C*      COMPUTE MASS FRACTIONS OF THE PRIMARY COMBUSTOR REACTANTS      *CCS
C*                                                                     *CCS
C***********************************************************************CCS
C                                                                       CCS
C                                                                       CCS
      WPRTOT=WPR1+WPR2+WPR3+WPR4                                        CCS
      WFPR1=WPR1/WPRTOT                                                 CCS
      WFPR2=WPR2/WPRTOT                                                 CCS
      WFPR3=WPR3/WPRTOT                                                 CCS
      WFPR4=WPR4/WPRTOT                                                 CCS
C                                                                       CCS
C                                                                       CCS
C***********************************************************************CCS
C*                                                                     *CCS
C*     COMPUTE PRIMARY COMBUSTOR PRODUCT MOLAR FLOW RATES (KMOLE/S)    *CCS
C*                                                                     *CCS
C***********************************************************************CCS
C                                                                       CCS
C                                                                       CCS
      XPP1=XPR1*N1                                                      CCS
      XPP4=XPR1*N2                                                      CCS
      XPP5=XPR2                                                         CCS
      XPP6=XPR3+0.5*XPR4*N3                                             CCS
      XPP3TM=XPR4*N4-XPP4-4.0*XPP1                                      CCS
      XPP3=ALPHA*XPP3TM                                                 CCS
      XPP2=0.5*(1.0-ALPHA)*XPP3TM                                       CCS
C                                                                       CCS
C                                                                       CCS
C***********************************************************************CCS
C*                                                                     *CCS
C*       COMPUTE PRIMARY COMBUSTOR PRODUCT MASS FLOW RATES (KG/S)      *CCS
C*                                                                     *CCS
C***********************************************************************CCS
C                                                                       CCS
C                                                                       CCS
      WPP1=XPP1*(12.0111+4.0*18.9984)                                   CCS
      WPP2=XPP2*37.9968                                                 CCS
      WPP3=XPP3*18.9984                                                 CCS
      IF(DFORHF.EQ.DF) WPP4=XPP4*(1.00797+18.9984)                      CCS
      IF(DFORHF.EQ.HF) WPP4=XPP4*(2.01410+18.9984)                      CCS
      WPP5=XPP5*4.00260                                                 CCS
      WPP6=XPP6*28.0134                                                 CCS
C                                                                       CCS
C                                                                       CCS
C***********************************************************************CCS
C*                                                                     *CCS
C*       COMPUTE MOLE FRACTIONS OF THE PRIMARY COMBUSTOR PRODUCTS      *CCS
C*                                                                     *CCS
C***********************************************************************CCS
C                                                                       CCS
C                                                                       CCS
      XPPTOT=XPP1+XPP2+XPP3+XPP4+XPP5+XPP6                              CCS
```

```
      XFPP1=XPP1/XPPTOT
      XFPP2=XPP2/XPPTOT
      XFPP3=XPP3/XPPTOT
      XFPP4=XPP4/XPPTOT
      XFPP5=XPP5/XPPTOT
      XFPP6=XPP6/XPPTOT
C
C
C***********************************************************************
C*                                                                     *
C*       COMPUTE MASS FRACTIONS OF THE PRIMARY COMBUSTOR PRODUCTS      *
C*                                                                     *
C***********************************************************************
C
C
      WPPTOT=WPP1+WPP2+WPP3+WPP4+WPP5+WPP6
      WFPP1=WPP1/WPPTOT
      WFPP2=WPP2/WPPTOT
      WFPP3=WPP3/WPPTOT
      WFPP4=WPP4/WPPTOT
      WFPP5=WPP5/WPPTOT
      WFPP6=WPP6/WPPTOT
      WP6WPP=WP6/WPPTOT
C
C
C***********************************************************************
C*                                                                     *
C*        COMPUTE SECONDARY REACTANT MOLAR FLOW RATES [KMOLE/S]        *
C*                                                                     *
C***********************************************************************
C
C
      IF(DFORHF.EQ.DF) XSR1=WSR1/4.02820
      IF(DFORHF.EQ.HF) XSR1=WSR1/2.01594
      XSR2=WSR2/4.00260
      XSR3=WSR3/28.0134
C
C
C***********************************************************************
C*                                                                     *
C*         COMPUTE MOLE FRACTIONS OF THE SECONDARY REACTANTS           *
C*                                                                     *
C***********************************************************************
C
C
      XSRTOT=XSR1+XSR2+XSR3
      XFSR1=XSR1/XSRTOT
      XFSR2=XSR2/XSRTOT
      XFSR3=XSR3/XSRTOT
C
C
C***********************************************************************
C*                                                                     *
C*         COMPUTE MASS FRACTIONS OF THE SECONDARY REACTANTS           *
C*                                                                     *
```

```
C***********************************************************************
C
C
      WSRTOT=WSR1+WSR2+WSR3
        SR1=WSR1/WSRTOT
      WFSR2=WSR2/WSRTOT
      WFSR3=WSR3/WSRTOT
C
C
C***********************************************************************
C*                                                                     *
C*         COMPUTE CAVITY PRODUCT MOLAR FLOW RATES (KMOLE/S)          *
C*                                                                     *
C***********************************************************************
C
C
      XCP1=XPP1
      IF(DFORHF.EQ.HF) GO TO 101
      XCP2=XPP4
      XCP3=2.0*XPP2+XPP3
      XCP6=2.0*XSR1-XCP3
      GO TO 102
101   XCP2=2.0*XPP2+XPP3
      XCP3=XPP4
      XCP6=2.0*XSR1-XCP2
102   XCP4=XPP5+XSR2
      XCP5=XPP6+XSR3
C***********************************************************************
C*                                                                     *
C*           COMPUTE CAVITY PRODUCT MASS FLOW RATES (KG/S)             *
C*                                                                     *
C***********************************************************************
C
C
      WCP1=XCP1*88.0047
      WCP2=XCP2*20.0064
      WCP3=XCP3*21.0125
      WCP4=XCP4*4.00260
      WCP5=XCP5*28.0134
      IF(DFORHF.EQ.DF) WCP6=XCP6*2.01410
      IF(DFORHF.EQ.HF) WCP6=XCP6*1.00797
C
C
C***********************************************************************
C*                                                                     *
C*            COMPUTE MOLE FRACTIONS OF THE CAVITY PRODUCTS            *
C*                     (1) WITHOUT MIRROR PURGE                        *
C*                     (2) WITH MIRROR PURGE                           *
C*                                                                     *
C***********************************************************************
C
C
      XCPTOT=XCP1+XCP2+XCP3+XCP4+XCP5+XCP6
      XFCP1(1)=XCP1/XCPTOT
      XFCP2(1)=XCP2/XCPTOT
```

```
      XFCP3(1)=XCP3/XCPTOT                                              CCS     3950
      XFCP4(1)=XCP4/XCPTOT                                              CCS     3960
      XFCP5(1)=XCP5/XCPTOT                                              CCS     3970
      XFCP6(1)=XCP6/XCPTOT                                              CCS     3980
      XCPTOT=XCPTOT+WP8/28.0134                                         CCS     3990
      XFCP1(2)=XCP1/XCPTOT                                              CCS     4000
      XFCP2(2)=XCP2/XCPTOT                                              CCS     4010
      XFCP3(2)=XCP3/XCPTOT                                              CCS     4020
      XFCP4(2)=XCP4/XCPTOT                                              CCS     4030
      XFCP5(2)=(XCP5+WP8/28.0134)/XCPTOT                                CCS     4040
      XFCP6(2)=XCP6/XCPTOT                                              CCS     4050
C                                                                       CCS     4060
C                                                                       CCS     4070
C***********************************************************************CCS     4080
C*                                                                     *CCS     4090
C*            COMPUTE MASS FRACTIONS OF THE CAVITY PRODUCTS            *CCS     4100
C*                         WITH MIRROR PURGE                           *CCS     4110
C*                                                                     *CCS     4120
C***********************************************************************CCS     4130
C                                                                       CCS     4140
C                                                                       CCS     4150
      WCPTOT=WCP1+WCP2+WCP3+WCP4+WCP5+WCP6+WP8                          CCS     4160
      WFCP1=WCP1/WCPTOT                                                 CCS     4170
      WFCP2=WCP2/WCPTOT                                                 CCS     4180
      WFCP3=WCP3/WCPTOT                                                 CCS     4190
      WFCP4=WCP4/WCPTOT                                                 CCS     4200
      WFCP5=(WCP5+WP8)/WCPTOT                                           CCS     4210
      WFCP6=WCP6/WCPTOT                                                 CCS     4220
C                                                                       CCS     4230
C                                                                       CCS     4240
C***********************************************************************CCS     4250
C*                                                                     *CCS     4260
C*                COMPUTE THE DILUENT AND MIXTURE RATIOS               *CCS     4270
C*                                                                     *CCS     4280
C*  NOTE: TRW ASSUMES EXCESS D2 IS NOT USED IN THE PSIL CALCULATION!   *CCS     4290
C*  HENCE, OMEGA IS DIFFERENT.                                         *CCS     4300
C*                                                                     *CCS     4310
C***********************************************************************CCS     4320
C                                                                       CCS     4330
C                                                                       CCS     4340
      PSIC=(XPP1+XPP4+XPP5+XPP6)/(XPP2+0.5*XPP3)                        CCS     4350
      PSIL=(XSR1+XSR2+XSR3)/(XPP2+0.5*XPP3)                             CCS     4360
      PSILTRW=(XSR2+XSR3)/(XPP2+0.5*XPP3)                               CCS     4370
      RC=(XPR4*N2)/(XPR1*(4.0*N1+N2))                                   CCS     4380
      RL=XSR1/(XPP2+0.5*XPP3)                                           CCS     4390
      RLF=(XSR1+XSR2+XSR3)/(XPP2+0.5*XPP3)                              CCS     4400
      OMEGA=PSIC+PSIL                                                   CCS     4410
      OMEGTRW=PSIC+PSILTRW                                              CCS     4420
C                                                                       CCS     4430
C                                                                       CCS     4440
C***********************************************************************CCS     4450
C*                                                                     *CCS     4460
C*                 COMPUTE THE AVALIABLE FLUORINE FLUX                 *CCS     4470
C*                                                                     *CCS     4480
C***********************************************************************CCS     4490
```

```
C
C
      FDAA=XPP3/AEXP
C
C
C***********************************************************************
C*                                                                     *
C*                   COMPUTE THE HEAT RELEASE WHERE:                   *
C*                                                                     *
C*         D2F = HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION         *
C*                            D2 + F = DF + D                          *
C*                                                                     *
C*         D2F2 = HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION        *
C*                            D2 + F2 = 2DF                            *
C*                                                                     *
C*         H2F = HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION         *
C*                            H2 + F = HF + H                          *
C*                                                                     *
C*         H2F2 = HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION        *
C*                            H2 + F2 = 2HF                            *
C*                                                                     *
C***********************************************************************
C
C
      IF(DFORHF.EQ.DF) Q=D2F*XFPP3+D2F2*XFPP2
      IF(DFORHF.EQ.HF) Q=H2F*XFPP3+H2F2*XFPP2
C
C
C***********************************************************************
C*                                                                     *
C*                           OUTPUT RESULTS                            *
C*                                                                     *
C***********************************************************************
C
C
103   CALL OUTCCS
      END
```

```
      SUBROUTINE INCCS                                                  INCCS  0100
C                                                                       INCCS  0110
C                                                                       INCCS  0120
C***********************************************************************INCCS  0130
C*                                                                     *INCCS  0140
C*                       INPUT SUBROUTINE (INCCS)                      *INCCS  0150
C*                                                                     *INCCS  0160
C***********************************************************************INCCS  0170
C                                                                       INCCS  0180
C***********************************************************************INCCS  0190
C*                                                                     *INCCS  0200
C*     SUBROUTINE INCCS CONTROLS THE INPUT OF INITIAL DATA FOR THE     *INCCS  0210
C*     COMBUSTION CHEMISTRY SECTION.                                   *INCCS  0220
C*                                                                     *INCCS  0230
C* INPUT/OUTPUT VARIABLES:                                             *INCCS  0240
C*                                                                     *INCCS  0250
C* AEXP   = NOZZLE BANK AREA OF THE EXPERIMENTAL DEVICE (M2)           *INCCS  0260
C* ALPHA  = FLUORINE DISSOCIATION FRACTION                             *INCCS  0270
C* CCSS1  = CONTROL VARIABLE                                           *INCCS  0280
C* CCSS2  = CONTROL VARIABLE                                           *INCCS  0290
C* DFORHF = CONTROL VARIABLE SUCH THAT:                                *INCCS  0300
C*        = "DF" FOR A DF CHEMICAL LASER                               *INCCS  0310
C*        = "HF" FOR A HF CHEMICAL LASER                               *INCCS  0320
C* N1     = NUMBER OF CARBON ATOMS IN REACTANT WPR1                    *INCCS  0330
C* N2     = NUMBER OF HYDROGEN ATOMS IN REACTANT WPR1                  *INCCS  0340
C* N3     = NUMBER OF NITROGEN ATOMS IN REACTANT WPR4                  *INCCS  0350
C* N4     = NUMBER OF FLUORINE ATOMS IN REACTANT WPR4                  *INCCS  0360
C* SETCCS = CONTROL VARIABLE                                           *INCCS  0370
C* WP6    = MASS FLOW RATE OF MIRROR PURGE N2 (KG/S)                   *INCCS  0380
C* WPR1   = MASS FLOW RATE OF C-N1 H-N2  (C-N1 D-N2) (KG/S)            *INCCS  0390
C* WPR2   = MASS FLOW RATE OF HE (KG/S)                                *INCCS  0400
C* WPR3   = MASS FLOW RATE OF N2 (KG/S)                                *INCCS  0410
C* WPR4   = MASS FLOW RATE OF N-N3 F-N4 (KG/S)                         *INCCS  0420
C* WSR1   = MASS FLOW RATE OF D2  (H2) (KG/S)                          *INCCS  0430
C* WSR2   = MASS FLOW RATE OF HE (KG/S)                                *INCCS  0440
C* WSR3   = MASS FLOW RATE OF N2 (KG/S)                                *INCCS  0450
C*                                                                     *INCCS  0460
C* NOTE: ALL INPUT IS IN SI UNITS.                                     *INCCS  0470
C*                                                                     *INCCS  0480
C***********************************************************************INCCS  0490
C                                                                       INCCS  0500
C                                                                       INCCS  0510
      REAL NO                                                           INCCS  0520
C                                                                       INCCS  0530
      COMMON/CCS1/CCSS1                                                 INCCS  0540
C                                                                       INCCS  0550
      COMMON/CCS2/AEXP,ALPHA,WP6,WPR1,WPR2,WPR3,WPR4,WSR1,WSR2,WSR3     INCCS  0560
C                                                                       INCCS  0570
      COMMON/CCS3/DFORHF                                                INCCS  0580
C                                                                       INCCS  0590
      COMMON/CCS5/N1,N2,N3,N4                                           INCCS  0600
C                                                                       INCCS  0610
      COMMON/MAIN3/SETCCS                                               INCCS  0620
C                                                                       INCCS  0630
      DATA NO/2HNO/,YES/3HYES/                                          INCCS  0640
```

```
C                                                                       INCCS  0650
      NAMELIST/NLCCS/AEXP,ALPHA,N1,N2,N3,N4,WPG,WPR1,WPR2,WPR3,WPR4,    INCCS  0660
     -WSR1,WSR2,WSR3                                                    INCCS  0670
C                                                                       INCCS  0680
C                                                                       INCCS  0690
C***********************************************************************INCCS  0700
C*                                                                     *INCCS  0710
C*                          SET DEFAULT VALUES                         *INCCS  0720
C*                                                                     *INCCS  0730
C***********************************************************************INCCS  0740
C                                                                       INCCS  0750
C                                                                       INCCS  0760
      WRITE(6,201)                                                      INCCS  0770
      READ(5,202)CCSS1                                                  INCCS  0780
      IF(SETCCS.EQ.NO) GO TO 101                                        INCCS  0790
      AEXP=3.61935E-03                                                  INCCS  0800
      ALPHA=0.802700                                                    INCCS  0810
      DFORHF=2HDF                                                       INCCS  0820
      N1=2                                                              INCCS  0830
      N2=4                                                              INCCS  0840
      N3=1                                                              INCCS  0850
      N4=3                                                              INCCS  0860
      WPG=0.0                                                           INCCS  0870
      WPR1=3.62160E-03                                                  INCCS  0880
      WPR2=17.2416E-03                                                  INCCS  0890
      WPR3=0.0                                                          INCCS  0900
      WPR4=57.1093E-03                                                  INCCS  0910
      WSR1=4.37250E-03                                                  INCCS  0920
      WSR2=33.8518E-03                                                  INCCS  0930
      WSR3=0.0                                                          INCCS  0940
      SETCCS=NO                                                         INCCS  0950
      IF(CCSS1.EQ.YES) GO TO 102                                        INCCS  0960
      CCSS1=YES                                                         INCCS  0970
      RETURN                                                            INCCS  0980
C                                                                       INCCS  0990
C                                                                       INCCS  1000
C***********************************************************************INCCS  1010
C*                                                                     *INCCS  1020
C*                          CONTROL STATEMENTS                         *INCCS  1030
C*                                                                     *INCCS  1040
C***********************************************************************INCCS  1050
C                                                                       INCCS  1060
C                                                                       INCCS  1070
101   IF(CCSS1.EQ.NO) RETURN                                            INCCS  1080
102   WRITE(6,203)                                                      INCCS  1090
      READ(5,202)CCSS2                                                  INCCS  1100
      IF(CCSS2.EQ.NO) GO TO 103                                         INCCS  1110
      REWIND 1                                                          INCCS  1120
      READ(1)AEXP,ALPHA,DFORHF,N1,N2,N3,N4,WPG,WPR1,WPR2,WPR3,WPR4,WSR1,INCCS  1130
     -WSR2,WSR3                                                         INCCS  1140
      RETURN                                                            INCCS  1150
103   WRITE(6,204)                                                      INCCS  1160
      READ(5,205)DFORHF                                                 INCCS  1170
      WRITE(6,206)                                                      INCCS  1180
      WRITE(6,207)AEXP,ALPHA,N1,N2,N3,N4,WPG,WPR1,WPR2,WPR3,WPR4,WSR1,  INCCS  1190
```

```
     -WSR2,WSR3
      READ(5,NLCCS)
      REWIND 1
      WRITE(1)AEXP,ALPHA,DFORHF,N1,N2,N3,N4,WPS,WPR1,WPR2,WPR3,WPR4,
     -WSR1,WSR2,WSR3
C
C
C***********************************************************************
C*                                                                     *
C*                           FORMAT STATEMENTS                         *
C*                                                                     *
C***********************************************************************
C
C
201   FORMAT(*1*,T2,*ARE NEW COMBUSTION CHEMISTRY INPUTS REQUIRED?*,/)
202   FORMAT(A3)
203   FORMAT(*0*,T2,*SHOULD INPUT DATA BE READ FROM TAPE1?*,/)
204   FORMAT(*1*,T2,*SELECT THE LASER CHEMISTRY FROM THE FOLLOWING LIST:
     -*,//,T2,*"DF" FOR A DF CHEMICAL LASER*,/,T2,*"HF" FOR A HF CHEMICA
     -L LASER*,/)
205   FORMAT(A2)
206   FORMAT(*1*,T2,*INPUT DATA FOR THE COMBUSTION CHEMISTRY SECTION BY
     -NAMELIST.*,/,T2,*CURRENT VALUES ARE:*)
207   FORMAT(* *,T2,*$NLCCS*,T26,*AEXP    =*,E13.6,T50,*ALPHA   =*,
     -E13.6,/,T2,*N1      =*,I13,T26,*N2      =*,I13,T50,*N3      =*,
     -I13,/,T2,*N4      =*,I13,T26,*WPS     =*,E13.6,T50,*WPR1    =*,
     -E13.6,/,T2,*WPR2    =*,E13.6,T26,*WPR3    =*,E13.6,T50,
     -*WPR4    =*,E13.6,/,T2,*WSR1    =*,E13.6,T26,*WSR2    =*,E13.6,
     -T50,*WSR3    =*,E13.6,* $*,/)
      END
```

```
      SUBROUTINE OUTCCS                                                 OUTCCS 0100
C                                                                       OUTCCS 0110
C                                                                       OUTCCS 0120
C***********************************************************************OUTCCS 0130
C*                                                                     *OUTCCS 0140
C*                       OUTPUT SUBROUTINE (OUTCCS)                    *OUTCCS 0150
C*                                                                     *OUTCCS 0160
C***********************************************************************OUTCCS 0170
C                                                                       OUTCCS 0180
C***********************************************************************OUTCCS 0190
C*                                                                     *OUTCCS 0200
C*  SUBROUTINE OUTCCS PRINTS THE COMBUSTION CHEMISTRY SECTION RESULTS  *OUTCCS 0210
C*  OF PROGRAM  CLAP IN SI  UNITS ON TERMINALS  WITH A MINIMUM OF 132  *OUTCCS 0220
C*  CHARACTERS PER LINE.                                               *OUTCCS 0230
C*                                                                     *OUTCCS 0240
C***********************************************************************OUTCCS 0250
C                                                                       OUTCCS 0260
C                                                                       OUTCCS 0270
      COMMON/CCS2/AEXP,ALPHA,WP6,WPR1,WPR2,WPR3,WPR4,WSR1,WSR2,WSR3     OUTCCS 0280
C                                                                       OUTCCS 0290
      COMMON/CCS3/DFORHF                                                OUTCCS 0300
C                                                                       OUTCCS 0310
      COMMON/CCS4/FDAA                                                  OUTCCS 0320
C                                                                       OUTCCS 0330
      COMMON/CCS5/N1,N2,N3,N4                                           OUTCCS 0340
C                                                                       OUTCCS 0350
      COMMON/CCS6/OMEGA,OMEGTRW,PSIC,PSIL,PSILTRW,RC,RLF,WFCP1,WFCP2,   OUTCCS 0360
     -WFCP3,WFCP4,WFCP5,WFCP6                                           OUTCCS 0370
C                                                                       OUTCCS 0380
      COMMON/CCS7/Q                                                     OUTCCS 0390
C                                                                       OUTCCS 0400
      COMMON/CCS8/RL                                                    OUTCCS 0410
C                                                                       OUTCCS 0420
      COMMON/CCS12/XFCP1(2),XFCP2(2),XFCP3(2),XFCP4(2),XFCP5(2),XFCP6(2)OUTCCS 0430
C                                                                       OUTCCS 0440
      DATA DF/2HDF/,HF/2HHF/                                            OUTCCS 0450
C                                                                       OUTCCS 0460
C                                                                       OUTCCS 0470
C***********************************************************************OUTCCS 0480
C*                                                                     *OUTCCS 0490
C*                          OUTPUT INITIAL DATA                        *OUTCCS 0500
C*                                                                     *OUTCCS 0510
C***********************************************************************OUTCCS 0520
C                                                                       OUTCCS 0530
C                                                                       OUTCCS 0540
      CALL DATE(RDATE)                                                  OUTCCS 0550
      WRITE(20,201)RDATE                                                OUTCCS 0560
      IF(DFORHF.EQ.DF) WRITE(20,202)AEXP,ALPHA,DFORHF,N1,N2,N3,N4,WP8,  OUTCCS 0570
     -WPR1,N1,N2,WPR2,WPR3,WPR4,N3,N4,WSR1,WSR2,WSR3                    OUTCCS 0580
      IF(DFORHF.EQ.HF) WRITE(20,203)AEXP,ALPHA,DFORHF,N1,N2,N3,N4,WP8,  OUTCCS 0590
     -WPR1,N1,N2,WPR2,WPR3,WPR4,N3,N4,WSR1,WSR2,WSR3                    OUTCCS 0600
C                                                                       OUTCCS 0610
C                                                                       OUTCCS 0620
C***********************************************************************OUTCCS 0630
C*                                                                     *OUTCCS 0640
```

```
C*                    OUTPUT RESULTANT DATA                               *OUTCCS 0650
C*                                                                        *OUTCCS 0660
C************************************************************************OUTCCS 0670
C                                                                         OUTCCS 0680
C                                                                         OUTCCS 0690
      WRITE(20,204)FDAA,OMEGA,OMEGTRW,PSIC,PSIL,PSILTRW,Q,RC,RL,RLF       OUTCCS 0700
      IF(DFORHF.EQ.DF) WRITE(20,205)WFCP1,XFCP1(2),WFCP2,XFCP2(2),WFCP3,OUTCCS 0710
     -XFCP3(2),WFCP4,XFCP4(2),WFCP5,XFCP5(2),WFCP6,XFCP6(2)              OUTCCS 0720
      IF(DFORHF.EQ.HF) WRITE(20,206)WFCP1,XFCP1(2),WFCP2,XFCP2(2),WFCP3,OUTCCS 0730
     -XFCP3(2),WFCP4,XFCP4(2),WFCP5,XFCP5(2),WFCP6,XFCP6(2)              OUTCCS 0740
C                                                                         OUTCCS 0750
C                                                                         OUTCCS 0760
C************************************************************************OUTCCS 0770
C*                                                                        *OUTCCS 0780
C*                    FORMAT STATEMENTS                                   *OUTCCS 0790
C*                                                                        *OUTCCS 0800
C************************************************************************OUTCCS 0810
C                                                                         OUTCCS 0820
C                                                                         OUTCCS 0830
201   FORMAT(*1*,///////,T47,*CHEMICAL LASER ANALYSIS PROGRAM (CLAP)*,//OUTCCS 0840
     -,T53,*WRITTEN BY: C.L. ADAMS*,/,T65,*A.L. ADDY*,/,T65,*R.D. MASSEYOUTCCS 0850
     -*,/,T65,*C.D. MIKKELSEN*,/,T65,*G.F. HORN*,/,T65,*R.L. OBLUKIAN*,/OUTCCS 0860
     -,T65,*B.J. WALKER*,//,T60,*1 JANUARY 77*,//,T51,*AERODYNAMICS GROUOUTCCS 0870
     -P (DRDMI-TDK)*,/,T51,*SYSTEM SIMULATION DIRECTORATE*,/,T42,*U.S. AOUTCCS 0880
     -RMY MISSILE RESEARCH & DEVELOPMENT COMMAND*,/,T51,*REDSTONE ARSENAOUTCCS 0890
     -L, ALABAMA 35809*,//,T57,*RUN DATE *,A10)                           OUTCCS 0900
202   FORMAT(*0*,///,T52,*COMBUSTION CHEMISTRY SECTION*,//,T60,         OUTCCS 0910
     -*INITIAL DATA:*,//,                                                 OUTCCS 0920
     -T32,*AEXP     =*,E13.6,* M2*,T66,*ALPHA    =*,E13.6,/,             OUTCCS 0930
     -T32,*DFORHF   =*,A13,T66,*N1       =*,I13,* ATOMS C*,/,            OUTCCS 0940
     -T32,*N2       =*,I13,* ATOMS H*,T66,*N3       =*,I13,* ATOMS N*,/,  OUTCCS 0950
     -T32,*N4       =*,I13,* ATOMS F*,T66,*WPG      =*,E13.6,* KG/S N2*,/,OUTCCS 0960
     -T32,*WPR1     =*,E13.6,* KG/S C*,I1,*H*,I1,                         OUTCCS 0970
     -T66,*WPR2     =*,E13.6,* KG/S HE*,/,T32,*WPR3     =*,E13.6,         OUTCCS 0980
     -* KG/S N2*,T66,*WPR4     =*,E13.6,* KG/S N*,I1,*F*,I1,/,T32,        OUTCCS 0990
     -*WSR1     =*,E13.6,* KG/S O2*,T66,*WSR2     =*,E13.6,* KG/S HE*,/,  OUTCCS 1000
     -T32,*WSR3     =*,E13.6,* KG/S N2*)                                  OUTCCS 1010
203   FORMAT(*0*,/////,T52,*COMBUSTION CHEMISTRY SECTION*,//,T60,        OUTCCS 1020
     -*INITIAL DATA:*,//,                                                 OUTCCS 1030
     -T32,*AEXP     =*,E13.6,* M2*,T66,*ALPHA    =*,E13.6,/,             OUTCCS 1040
     -T32,*DFORHF   =*,A13,T66,*N1       =*,I13,* ATOMS C*,/,            OUTCCS 1050
     -T32,*N2       =*,I13,* ATOMS D*,T66,*N3       =*,I13,* ATOMS N*,/,  OUTCCS 1060
     -T32,*N4       =*,I13,* ATOMS F*,T66,*WPG      =*,E13.6,* KG/S N2*,/,OUTCCS 1070
     -T32,*WPR1     =*,E13.6,* KG/S C*,I1,*D*,I1,                         OUTCCS 1080
     -T66,*WPR2     =*,E13.6,* KG/S HE*,/,T32,*WPR3     =*,E13.6,         OUTCCS 1090
     -* KG/S N2*,T66,*WPR4     =*,E13.6,* KG/S N*,I1,*F*,I1,/,T32,        OUTCCS 1100
     -*WSR1     =*,E13.6,* KG/S H2*,/,T66,*WSR2     =*,E13.6,* KG/S HE*,/,OUTCCS 1110
     -T32,*WSR3     =*,E13.6,* KG/S N2*)                                  OUTCCS 1120
204   FORMAT(*0*,T59,*RESULTANT DATA:*,//,                               OUTCCS 1130
     -T32,*FDAA     =*,E13.6,* KMOLE/S-M2*,T66,*OMEGA    =*,E13.6,/,     OUTCCS 1140
     -T32,*OMEGTRW =*,E13.6,T66,*PSIC     =*,E13.6,/,                    OUTCCS 1150
     -T32,*PSIL     =*,E13.6,T66,*PSILTRW =*,E13.6,/,                    OUTCCS 1160
     -T32,*Q        =*,E13.6,* J/KMOLE*,T66,*RC       =*,E13.6,/,        OUTCCS 1170
     -T32,*RL       =*,E13.6,T66,*RLF      =*,E13.6)                     OUTCCS 1180
205   FORMAT(*0*,                                                         OUTCCS 1190
```

```
     -T32,*WFCP1    =*,E13.6,* CF4*,T66,*XFCP1    =*,E13.6,* CF4*,/,    OUTCCS 1200
     -T32,*WFCP2    =*,E13.6,* HF*,T66,*XFCP2    =*,E13.6,* HF*,/,      OUTCCS 1210
     -T32,*WFCP3    =*,E13.6,* DF*,T66,*XFCP3    =*,E13.6,* DF*,/,      OUTCCS 1220
     -T32,*WFCP4    =*,E13.6,* HE*,T66,*XFCP4    =*,E13.6,* HE*,/,      OUTCCS 1230
     -T32,*WFCP5    =*,E13.6,* N2*,T66,*XFCP5    =*,E13.6,* N2*,/,      OUTCCS 1240
     -T32,*WFCP6    =*,E13.6,* D*,T66,*XFCP6    =*,E13.6,* D*)          OUTCCS 1250
206   FORMAT(*0*,                                                        OUTCCS 1260
     -T32,*WFCP1    =*,E13.6,* CF4*,T66,*XFCP1    =*,E13.6,* CF4*,/,    OUTCCS 1270
     -T32,*WFCP2    =*,E13.6,* HF*,T66,*XFCP2    =*,E13.6,* HF*,/,      OUTCCS 1280
     -T32,*WFCP3    =*,E13.6,* DF*,T66,*XFCP3    =*,E13.6,* DF*,/,      OUTCCS 1290
     -T32,*WFCP4    =*,E13.6,* HE*,T66,*XFCP4    =*,E13.6,* HE*,/,      OUTCCS 1300
     -T32,*WFCP5    =*,E13.6,* N2*,T66,*XFCP5    =*,E13.6,* N2*,/,      OUTCCS 1310
     -T32,*WFCP6    =*,E13.6,* H*,T66,*XFCP6    =*,E13.6,* H*)          OUTCCS 1320
      END                                                                OUTCCS 1330
```

Appendix C. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)–OVERLAY LDS

```
      OVERLAY(LDS,2,0)
      PROGRAM LDS
C
C
C***********************************************************************
C*                                                                     *
C*                    LASER DEVICE OVERLAY (LDS)                       *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C*   OVERLAY LDS CONTROLS THE LASER DEVICE  CALCULATIONS FOR PROGRAM   *
C*   CLAP.                                                             *
C*                                                                     *
C*                       GENERAL NOTATION SCHEME                       *
C*                                                                     *
C* VARIABLES ARE DEFINED AS FOLLOWS:                                   *
C*                                                                     *
C* A : AREA PER KMOLE/S OF PRIMARY FLOW (S-M2/KMOLE)                   *
C* D : DIAMETER (M)                                                    *
C* G : (GAMMA) SPECIFIC HEAT RATIO                                     *
C* M : MACH NUMBER                                                     *
C* MW: MOLECULAR WEIGHT (KG/KMOLE)                                     *
C* P : PRESSURE (PA)                                                   *
C* R : DENSITY (KG/M3)                                                 *
C* RE: REYNOLDS NUMBER                                                 *
C* T : TEMPERATURE (K)                                                 *
C* W : MASS FLOW RATE (KG/S)                                           *
C* X : MOLAR FLOW RATE (KMOLE/S)                                       *
C*                                                                     *
C* REPEATED LETTERS INDICATE RATIOS.                                   *
C* EXAMPLE: W6W2=W6/W2                                                 *
C*                                                                     *
C* VARIABLES ARE DESIGNATED AS TO LOCATION BY THE FOLLOWING:           *
C*                                                                     *
C* POINT 1: PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE       *
C*          STAGNATION (COMBUSTOR) TEMPERATURE                         *
C* POINT 2: PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE       *
C*          EXIT TEMPERATURE                                           *
C* POINT 3: SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE     *
C*          STAGNATION (COMBUSTOR) TEMPERATURE                         *
C* POINT 4: SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE     *
C*          EXIT TEMPERATURE                                           *
C* POINT 5: EXIT OF THE CONSTANT-AREA MIXING REGION                    *
C* POINT 6: EXIT OF THE ISENTROPIC EXPANSION REGION                    *
C* POINT 7: MIRROR PURGE CONDITIONS                                    *
C* POINT 8: LASER CAVITY EXIT                                          *
C* EXAMPLE: MW8 = MOLECULAR WEIGHT AT THE CAVITY EXIT                  *
C*                                                                     *
C* E: INDICATES "EFFECTIVE" CONDITIONS                                 *
C* G: INDICATES "GEOMETRIC" CONDITIONS                                 *
C* S: INDICATES "*" CONDITIONS                                         *
C* 0: INDICATES STAGNATION CONDITIONS                                  *
C* EXAMPLE: A1A1S0 = A/A* AT THE PRIMARY NOZZLE EXIT BASED ON THE      *
```

```
C*         NOZZLE GEOMETRY                                             *LDS    0650
C*                                                                     *LDS    0660
C* VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED AS REQUIRED.        *LDS    0670
C*                                                                     *LDS    0680
C***********************************************************************LDS    0690
C                                                                       LDS    0700
C                                                                       LDS    0710
      IMPLICIT REAL(L,M,N)                                              LDS    0720
C                                                                       LDS    0730
      DIMENSION XF(11)                                                  LDS    0740
C                                                                       LDS    0750
      COMMON/CCS1/CCSS1                                                 LDS    0760
C                                                                       LDS    0770
      COMMON/CCS3/DFORHF                                                LDS    0780
C                                                                       LDS    0790
      COMMON/CCS7/Q                                                     LDS    0800
C                                                                       LDS    0810
      COMMON/CCS11/W7W2                                                 LDS    0820
C                                                                       LDS    0830
      COMMON/CCS12/XFCP1(2),XFCP2(2),XFCP3(2),XFCP4(2),XFCP5(2),XFCP6(2)LDS    0840
C                                                                       LDS    0850
      COMMON/LDS1/LDSS1                                                 LDS    0860
C                                                                       LDS    0870
      COMMON/LDS2/D1,D1S,D3,D3S,GEOMPN,GEOMSN,LDSS2,LPNOZ,LSNOZ,NSPNOZ, LDS    0880
     -PKFRAC,P10,T10,T30,T70                                            LDS    0890
C                                                                       LDS    0900
      COMMON/LDS3/A1,A1A1SE,A1A1SG,A2,A3,A3A3SE,A3A3SG,A4,A5,A6,G1,G2,  LDS    0910
     -G3,G4,G5,G6,G7,LSEP,MW1,MW2,MW3,MW4,MW5,MW6,MW7,M1,M2,M3,M4,M5,M6,LDS    0920
     -NPNOZ,NSNOZ,P1,P2,P3,P30,P4,P5,P50,P6,P60,RE1,RE3,RE8,R1,R10,R2,  LDS    0930
     -R20,R3,R30,R4,R40,R5,R50,R6,R60,T1,T2,T20,T3,T4,T40,T5,T50,T6,T60,LDS    0940
     -W3W1,W5W2,W6W2,W8W2,X3X1,X4X2,X5X2,X6X2,X7X2,X8X2                 LDS    0950
C                                                                       LDS    0960
      COMMON/LDS4/A8,G8,MW8,M8,P8,P80,R8,R80,T8,T80                     LDS    0970
C                                                                       LDS    0980
      COMMON/LDS5/BRFRAC,CANGLE,HBASE,HNB,LCAV                          LDS    0990
C                                                                       LDS    1000
      COMMON/LDS6/P20,P40,W4W2                                          LDS    1010
C                                                                       LDS    1020
      COMMON/MAIN1/FAIL                                                 LDS    1030
C                                                                       LDS    1040
      COMMON/MAIN2/FLOW                                                 LDS    1050
C                                                                       LDS    1060
      DATA RBAR/8.31434E+03/                                            LDS    1070
      DATA CHOKE/5HCHOKE/,HF/2HHF/,NO/2HNO/,SUP/3HSUP/,YES/3HYES/       LDS    1080
C                                                                       LDS    1090
C                                                                       LDS    1100
C***********************************************************************LDS    1110
C*                                                                     *LDS    1120
C*                        GAS DYNAMIC FUNCTIONS                        *LDS    1130
C*                                                                     *LDS    1140
C***********************************************************************LDS    1150
C                                                                       LDS    1160
C                                                                       LDS    1170
      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M                                     LDS    1180
      POPM(G,M)=TOTM(G,M)**(G/(G-1.0))                                  LDS    1190
```

```
      RORM(G,M)=TOTM(G,M)**(1.0/(G-1.0))
      RHO(P,T,MW)=P*MW/(RBAR*T)
      WM(G,M)=M*SQRT(G*TOTM(G,M))
C
C
C***********************************************************************
C*                                                                     *
C*     INITIALIZE VARIABLES FOR MULTIPLE RUNS AND READ INPUT DATA      *
C*                                                                     *
C***********************************************************************
C
C
      CALL INLDS
      IF(CCSS1.EQ.YES) LDSS1=YES
      IF(LDSS1.EQ.NO) GO TO 105
      FLOW=SUP
C
C
C***********************************************************************
C*                                                                     *
C*                 LASER PRIMARY NOZZLE CALCULATIONS                   *
C*                                                                     *
C***********************************************************************
C
C
      CALL LPNCS(D1,D1S,D3,GEOMPN,GEOMSN,HNB,LDSS2,LPNOZ,NSPNOZ,PKFRAC,
     -P10,T10,A1A1SE,A1A1SG,A1,A2,A6,FAIL,G1,G2,M1,MW1,NPNOZ,P1,RE1,T1)
      IF(FAIL.EQ.YES) GO TO 106
      R1=RHO(P1,T1,MW1)
      R10=RHO(P10,T10,MW1)
      M2=M1
      MW2=MW1
      P2=P1
      P20=P10
      T2=T1
      T20=T10
      R2=R1
      R20=R10
C
C
C***********************************************************************
C*                                                                     *
C*                LASER SECONDARY NOZZLE CALCULATIONS                  *
C*                                                                     *
C***********************************************************************
C
C
      IF(D3.NE.D3S) CALL LSNCS1(D3,D3S,GEOMSN,HNB,LSNOZ,NPNOZ,NSPNOZ,
     -T30,A3A3SE,A3A3SG,A3,A4,FAIL,G3,G4,M3,MW3,NSNOZ,P3,P30,RE3,T3,
     -X3X1)
      IF(FAIL.EQ.YES) GO TO 107
      IF(D3.EQ.D3S) CALL LSNCS2(D3,D3S,GEOMSN,HNB,LSNOZ,NPNOZ,NSPNOZ,
     -T30,A3A3SE,A3A3SG,A3,A4,FAIL,G3,G4,M3,MW3,NSNOZ,P3,P30,RE3,T3,
     -X3X1)
      IF(FAIL.EQ.YES) GO TO 108
```

```
      R3=RHO(P3,T3,MW3)
      R30=RHO(P30,T30,MW3)
      W3W1=X3X1*MW3/MW1
      M4=M3
      MW4=MW3
      P4=P3
      P40=P30
      T4=T3
      T40=T30
      R4=R3
      R40=R30
      W4W2=W3W1
      X4X2=X3X1
C
C
C***********************************************************************
C*                                                                     *
C*                    CONSTANT-AREA MIXING CALCULATIONS                *
C*                                                                     *
C***********************************************************************
C
C
      A4A2=A4/A2
      MW4MW2=MW4/MW2
      P4P2=P4/P2
      T40T20=T40/T20
      CALL CAMS(A4A2,FLOW,G2,G4,M2,M4,MW4MW2,P4P2,T40T20,FAIL,G5,M5,
     -MW5MW2,P5P2,T50T20)
      IF(FAIL.EQ.YES) GO TO 109
      A5=A2+A4
      MW5=MW5MW2*MW2
      P5=P5P2*P2
      P50=POPM(G5,M5)*P5
      T50=T50T20*T20
      T5=T50/TOTM(G5,M5)
      R5=RHO(P5,T5,MW5)
      R50=RHO(P50,T50,MW5)
      X5X2=1.0+X4X2
      W5W2=1.0+W4W2
C
C
C***********************************************************************
C*                                                                     *
C*                    ISENTROPIC EXPANSION CALCULATIONS                *
C*                                                                     *
C***********************************************************************
C
C
      A6=A6/BRFHAC
      A6A5=A6/A5
      CALL EXPAN(G5,M5,A6A5,M6,P6P5,P60P50,T6T5,T60T50,FAIL)
      IF(FAIL.EQ.YES) GO TO 110
      G6=G5
      MW6=MW5
      P6=P6P5*P5
```

```
      P60=P60P50*P50                                                    LDS     2300
      T6=T6T5*T5                                                        LDS     2310
      T60=T60T50*T50                                                    LDS     2320
      R6=RHO(P6,T6,MW6)                                                 LDS     2330
      R60=RHO(P60,T60,MW6)                                              LDS     2340
      X6X2=X5X2                                                         LDS     2350
      W6W2=W5W2                                                         LDS     2360
C                                                                       LDS     2370
C                                                                       LDS     2380
C***********************************************************************LDS     2390
C*                                                                     *LDS     2400
C*                         LASER CAVITY CALCULATIONS                   *LDS     2410
C*                                                                     *LDS     2420
C***********************************************************************LDS     2430
C                                                                       LDS     2440
C                                                                       LDS     2450
      A8=A6*(1.0+2.0*LCAV*TAN(CANGLE)/HBASE)                            LDS     2460
      XF(1)=XFCP1(1)                                                    LDS     2470
      XF(2)=0.0                                                         LDS     2480
      XF(3)=0.0                                                         LDS     2490
      XF(4)=XFCP2(1)                                                    LDS     2500
      XF(5)=XFCP3(1)                                                    LDS     2510
      XF(6)=XFCP4(1)                                                    LDS     2520
      XF(7)=XFCP5(1)                                                    LDS     2530
      XF(8)=0.0                                                         LDS     2540
      XF(9)=0.0                                                         LDS     2550
      IF(DFORHF.EQ.HF) GO TO 101                                        LDS     2560
      XF(10)=XFCP6(1)                                                   LDS     2570
      XF(11)=0.0                                                        LDS     2580
      GO TO 102                                                         LDS     2590
  101 XF(10)=0.0                                                        LDS     2600
      XF(11)=XFCP6(1)                                                   LDS     2610
  102 TP=Q*(G5-1.0)/(G5*RBAR*X5X2)+T5                                   LDS     2620
      CALL CPCALC(1,11,TP,XF,GP,MWP)                                    LDS     2630
      XF(7)=1.0                                                         LDS     2640
      CALL CPCALC(7,7,T70,XF,G7,MW7)                                    LDS     2650
      A8A6=A8/A6                                                        LDS     2660
      MWPMW6=MWP/MW6                                                    LDS     2670
      MW7MW6=MW7/MW6                                                    LDS     2680
      Q6R=Q*(G6-1.0)/(T6*G6*RBAR*X6X2)                                  LDS     2690
      T70T6=T70/T6                                                      LDS     2700
      W7W6=W7W2/W6W2                                                    LDS     2710
      CALL LCAS(A8A6,G7,GP,G6,MW7MW6,MWPMW6,M5,M6,P6P5,Q6R,T70T6,W7W6,  LDS     2720
     -FLOW,G8,MW8MW6,M8,P8P6,P80P60,T8T6,T80T60,X8X6,LSLCAV)            LDS     2730
      IF(FLOW.EQ.CHOKE) GO TO 105                                       LDS     2740
      MW8=MW8MW6*MW6                                                    LDS     2750
      P8=P8P6*P6                                                        LDS     2760
      P80=P80P60*P60                                                    LDS     2770
      T8=T8T6*T6                                                        LDS     2780
      T80=T80T60*T60                                                    LDS     2790
      R8=RHO(P8,T8,MW8)                                                 LDS     2800
      R80=RHO(P80,T80,MW8)                                              LDS     2810
      X8X2=X8X6*X6X2                                                    LDS     2820
      W8W2=X8X2*MW8/MW2                                                 LDS     2830
      LSEP=LSLCAV*LCAV                                                  LDS     2840
```

```
      XF(1)=XFCP1(2)                                                    LDS    2850
      XF(4)=XFCP2(2)                                                    LDS    2860
      XF(5)=XFCP3(2)                                                    LDS    2870
      XF(6)=XFCP4(2)                                                    LDS    2880
      XF(7)=XFCP5(2)                                                    LDS    2890
      IF(DFORHF.EQ.HF) GO TO 103                                        LDS    2900
      XF(10)=XFCP6(2)                                                   LDS    2910
      GO TO 104                                                         LDS    2920
103   XF(11)=XFCP6(2)                                                   LDS    2930
104   CALL VISC(1,11,XF,A,B)                                            LDS    2940
      REA=RB*MB*SQRT(GB*RBAR*TB/MWB)*(HBASE+2.0*LCAV*TAN(CANGLE))/      LDS    2950
     -EXP(A*ALOG(TB)+B)                                                 LDS    2960
C                                                                       LDS    2970
C                                                                       LDS    2980
C***********************************************************************LDS    2990
C*                                                                     *LDS    3000
C*                           OUTPUT RESULTS                            *LDS    3010
C*                                                                     *LDS    3020
C***********************************************************************LDS    3030
C                                                                       LDS    3040
C                                                                       LDS    3050
      WRITE(6,206)(T10,P10,K=1,10)                                      LDS    3060
105   CALL OUTLDS                                                       LDS    3070
      GO TO 207                                                         LDS    3080
C                                                                       LDS    3090
C                                                                       LDS    3100
C***********************************************************************LDS    3110
C*                                                                     *LDS    3120
C*                         FAILURE INDICATORS                          *LDS    3130
C*                                                                     *LDS    3140
C***********************************************************************LDS    3150
C                                                                       LDS    3160
C                                                                       LDS    3170
106   WRITE(6,201)                                                      LDS    3180
      GO TO 207                                                         LDS    3190
107   WRITE(6,202)                                                      LDS    3200
108   WRITE(6,203)                                                      LDS    3210
      GO TO 207                                                         LDS    3220
109   WRITE(6,204)                                                      LDS    3230
      FAIL=YES                                                          LDS    3240
      GO TO 207                                                         LDS    3250
110   WRITE(6,205)                                                      LDS    3260
C                                                                       LDS    3270
C                                                                       LDS    3280
C***********************************************************************LDS    3290
C*                                                                     *LDS    3300
C*                         FORMAT STATEMENTS                           *LDS    3310
C*                                                                     *LDS    3320
C***********************************************************************LDS    3330
C                                                                       LDS    3340
C                                                                       LDS    3350
201   FORMAT(*0*,T2,*SUBROUTINE LPNCS WAS CALLED FROM SUBROUTINE LDS*)  LDS    3360
202   FORMAT(*0*,T2,*SUBROUTINE LSNCS1 WAS CALLED FROM SUBROUTINE LDS*) LDS    3370
203   FORMAT(*0*,T2,*SUBROUTINE LSNCS2 WAS CALLED FROM SUBROUTINE LDS*) LDS    3380
204   FORMAT(*0*,T2,*FAILURE IN SUBROUTINE CAMS AS CALLED FROM SUBROUTINLDS    3390
```

```
     -E LDS*)                                                           LDS     3400
205   FORMAT(*0*,T2,*SURROUTINE EXPAN WAS CALLED FROM SUBROUTINE LDS*)  LDS     3410
206   FORMAT(*1*,10(T2,*NOTE: T10 =*,F13.6,* K   P10 =*,F13.6,* PA*,/)) LDS     3420
207   END                                                               LDS     3430
```

```
      SUBROUTINE CAMS(AS1AP1,FLOW,GP,GS,MP1,MS1,MWSMWP,PS1PP1,TS0TP0,
     -FAIL,GM,MM3,MWMMWP,PM3PP1,TM0TP0)
C
C
C***********************************************************************
C*                                                                     *
C*                  CONSTANT-AREA MIXING SUBROUTINE (CAMS)             *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C* SUBROUTINE  CAMS  PERFORMS  THE  CONSTANT-AREA,  ADIABATIC,  MIXING *
C* CALCULATIONS BY ONE-DIMENSIONAL ANALYSIS FOR TWO UNIFORM STREAMS AT *
C* INLET STATION (1)  MIXING TO A UNIFORM STREAM AT MIXED STATION (3). *
C*                                                                     *
C* INPUT VARIABLES:                                                    *
C*                                                                     *
C* AS1AP1 = SECONDARY-TO-PRIMARY STREAM AREA RATIO                     *
C* FLOW   = CONTROL VARIABLE SUCH THAT:                                *
C*        = "SUB" FOR THE SUBSONIC SOLUTION                            *
C*        = "SUP" FOR THE SUPERSONIC SOLUTION                          *
C* GP     = PRIMARY STREAM GAMMA                                       *
C* GS     = SECONDARY STREAM GAMMA                                     *
C* MP1    = PRIMARY STREAM MACH NO.                                    *
C* MS1    = SECONDARY STREAM MACH NO.                                  *
C* MWSMWP = SECONDARY-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO         *
C* PS1PP1 = SECONDARY-TO-PRIMARY STREAM STATIC PRESSURE RATIO          *
C* TS0TP0 = SECONDARY-TO-PRIMARY STREAM STAGNATION TEMPERATURE RATIO   *
C*                                                                     *
C* OUTPUT VARIABLES:                                                   *
C*                                                                     *
C* FAIL   = ERROR FLAG                                                 *
C* GM     = MIXED STREAM GAMMA                                         *
C* MM3    = MIXED STREAM MACH NO.                                      *
C* MWMMWP = MIXED-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO             *
C* PM3PP1 = MIXED-TO-PRIMARY STREAM STATIC PRESSURE RATIO              *
C* TM0TP0 = MIXED-TO-PRIMARY STREAM STAGNATION TEMPERATURE RATIO       *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
      DATA SUP/3HSUP/,YES/3HYES/
C
C
C***********************************************************************
C*                                                                     *
C*                          SPECIAL FUNCTIONS                          *
C*                                                                     *
C***********************************************************************
C
C
      F(G,M)=1.0+G*M*M
      G(G,M)=M*SQRT(1.0+0.5*(G-1.0)*M*M)
```

```
      M(MM,TT,GG)=SQRT(MM*GG/TT)                                        CAMS   0650
C                                                                       CAMS   0660
C                                                                       CAMS   0670
C***********************************************************************CAMS   0680
C*                                                                     *CAMS   0690
C*                         CALCULATE CONSTANTS                         *CAMS   0700
C*                                                                     *CAMS   0710
C***********************************************************************CAMS   0720
C                                                                       CAMS   0730
C                                                                       CAMS   0740
      GS3=GS/(GS-1.0)                                                   CAMS   0750
      GP3=GP/(GP-1.0)                                                   CAMS   0760
      GSGP=GS/GP                                                        CAMS   0770
      MWPMWS=1.0/MWSMWP                                                 CAMS   0780
C                                                                       CAMS   0790
C                                                                       CAMS   0800
C***********************************************************************CAMS   0810
C*                                                                     *CAMS   0820
C*                 OVERALL CONTROL VOLUME CALCULATIONS                 *CAMS   0830
C*                                                                     *CAMS   0840
C***********************************************************************CAMS   0850
C                                                                       CAMS   0860
C                                                                       CAMS   0870
      WSWP=PS1PP1*AS1AP1*M(MWSMWP,TSOTP0,GSGP)*G(GS,MS1)/G(GP,MP1)      CAMS   0880
      C1=WSWP*MWPMWS*GS3+GP3                                            CAMS   0890
      C2=WSWP*MWPMWS*(GS3-1.0)+(GP3-1.0)                                CAMS   0900
      GM=C1/C2                                                          CAMS   0910
      GMGP=GM/GP                                                        CAMS   0920
      MWMMWP=(WSWP+1.0)/(WSWP*MWPMWS+1.0)                               CAMS   0930
      C1=TSOTP0*WSWP*MWPMWS*GS3+GP3                                     CAMS   0940
      C2=WSWP*MWPMWS*GS3+GP3                                            CAMS   0950
      TMOTP0=C1/C2                                                      CAMS   0960
      FFX=M(MWMMWP,TMOTP0,GMGP)*(PS1PP1*AS1AP1*F(GS,MS1)+F(GP,MP1))/    CAMS   0970
     -((1.0+WSWP)*G(GP,MP1))                                            CAMS   0980
      C1=0.5*(GM-1.0)*FFX*FFX-GM*GM                                     CAMS   0990
      C2=FFX*FFX-2.0*GM                                                 CAMS   1000
      C3=(-C2+SQRT(C2*C2+4.0*C1))/(2.0*C1)                              CAMS   1010
      C4=(-C2-SQRT(C2*C2+4.0*C1))/(2.0*C1)                              CAMS   1020
C                                                                       CAMS   1030
C                                                                       CAMS   1040
C***********************************************************************CAMS   1050
C*                                                                     *CAMS   1060
C*             IDENTIFY THE SUBSONIC AND SUPERSONIC SOLUTIONS          *CAMS   1070
C*                                                                     *CAMS   1080
C***********************************************************************CAMS   1090
C                                                                       CAMS   1100
C                                                                       CAMS   1110
      IF(FLOW.EQ.SUP) GO TO 101                                         CAMS   1120
      IF(C3.LT.0.0.OR.C4.LT.0.0) MM3=SQRT(AMAX1(C3,C4))                 CAMS   1130
      IF(C3.GE.0.0.AND.C4.GE.0.0) MM3=SQRT(AMIN1(C3,C4))                CAMS   1140
      GO TO 102                                                         CAMS   1150
101   IF(C3.LT.0.0.OR.C4.LT.0.0) GO TO 103                              CAMS   1160
      MM3=SQRT(AMAX1(C3,C4))                                            CAMS   1170
102   PM3PP1=(PS1PP1*AS1AP1*F(GS,MS1)+F(GP,MP1))/((1.0+AS1AP1)*         CAMS   1180
     -F(GM,MM3))                                                        CAMS   1190
```

```
      RETURN                                                            CAMS    1200
C                                                                       CAMS    1210
C                                                                       CAMS    1220
C***********************************************************************CAMS    1230
C*                                                                     *CAMS    1240
C*                         FAILURE INDICATORS                          *CAMS    1250
C*                                                                     *CAMS    1260
C***********************************************************************CAMS    1270
C                                                                       CAMS    1280
C                                                                       CAMS    1290
103   WRITE(6,201)MS1,MP1                                               CAMS    1300
      FAIL=YES                                                          CAMS    1310
201   FORMAT(*1*,T2,*NO SUPERSONIC SOLUTION EXITS FOR*,/,T2,*MS1    =*, CAMS    1320
     -E13.6,2X,*MP1    =*,E13.6)                                        CAMS    1330
      END                                                               CAMS    1340
```

```
      SUBROUTINE CPCALC(NS1,NS2,TDZ,XF,GMIX,MWMIX)                      CPCALC 0100
C                                                                       CPCALC 0110
C                                                                       CPCALC 0120
C***********************************************************************CPCALC 0130
C*                                                                     *CPCALC 0140
C*          SPECIFIC HEAT CALCULATION SUBROUTINE (CPCALC)              *CPCALC 0150
C*                                                                     *CPCALC 0160
C***********************************************************************CPCALC 0170
C                                                                       CPCALC 0180
C***********************************************************************CPCALC 0190
C*                                                                     *CPCALC 0200
C* SUBROUTINE CPCALC CALCULATES THE SPECIFIC HEAT AT CONSTANT PRESSURE *CPCALC 0210
C* OF MIXTURES OF GASES.                                               *CPCALC 0220
C*                                                                     *CPCALC 0230
C* INPUT VARIABLES:                                                    *CPCALC 0240
C*                                                                     *CPCALC 0250
C* NS1     = DO LOOP LIMIT                                             *CPCALC 0260
C* NS2     = DO LOOP LIMIT                                             *CPCALC 0270
C* TDZ     = TEMPERATURE OF MIXTURE [K]                                *CPCALC 0280
C* XF(I)   = MOLE FRACTION OF THE I-TH SPECIES                         *CPCALC 0290
C*                                                                     *CPCALC 0300
C* OUTPUT VARIABLES:                                                   *CPCALC 0310
C*                                                                     *CPCALC 0320
C* GMIX    = SPECIFIC HEAT RATIO OF THE MIXTURE                        *CPCALC 0330
C* MWMIX   = MOLECULAR WEIGHT OF THE MIXTURE [KG/KMOLE]                *CPCALC 0340
C*                                                                     *CPCALC 0350
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS.                   *CPCALC 0360
C*                                                                     *CPCALC 0370
C***********************************************************************CPCALC 0380
C                                                                       CPCALC 0390
C                                                                       CPCALC 0400
      IMPLICIT REAL(M)                                                  CPCALC 0410
      DIMENSION CP(11,31),MW(11),XF(11)                                 CPCALC 0420
C                                                                       CPCALC 0430
      DATA MW/                                                          CPCALC 0440
C            CF4           F2           F            HF           DF    CPCALC 0450
     -     88.0047,    37.9968,     18.9984,      20.0064,      21.0125,CPCALC 0460
C             HE           N2           D2           H2            D    CPCALC 0470
     -     4.00260,    28.0134,     4.02820,      2.01594,      2.01410,CPCALC 0480
C              H                                                        CPCALC 0490
     -     1.00797/                                                     CPCALC 0500
C                                                                       CPCALC 0510
C                                                                       CPCALC 0520
C***********************************************************************CPCALC 0530
C*                                                                     *CPCALC 0540
C* CP VALUES ARE STORED IN UNITS OF [1.0E-04 J/KMOLE-K] AND TABULATED  *CPCALC 0550
C* BY TEMPERATURE (ROW) FROM 0 K TO 3000 K IN INCREMENTS OF 100 K AND  *CPCALC 0560
C* SPECIES (COLUMN).                                                   *CPCALC 0570
C*                                                                     *CPCALC 0580
C* CP DATA WAS TAKEN FROM:  JANAF THERMOCHEMICAL  TABLES, 2ND EDITION  *CPCALC 0590
C* EXCEPT  VALUES FOR D2 AND DF WHICH WERE  TAKEN FROM  LOCKHEED DATA. *CPCALC 0600
C*                                                                     *CPCALC 0610
C* NOTE: CP VALUES  AT 0 K ARE  INCLUDED FOR  INTERPOLATION  PURPOSES  *CPCALC 0620
C* ONLY.  CP VALUES AT 0 K ARE TAKEN EQUAL TO THOSE AT 100 K SINCE CP  *CPCALC 0630
C* IS  NEARLY  CONSTANT FOR MOST  GASES FROM 100 K TO THE  SATURATION  *CPCALC 0640
```

```
C* POINT,                                                              *CPCALC 0650
C*                                                                     *CPCALC 0660
C**********************************************************************CPCALC 0670
C                                                                       CPCALC 0680
C                                                                       CPCALC 0690
      DATA ((CP(I,J),I=1,9),J=1,11)/                                    CPCALC 0700
C        CF4     F2      F       HF      DF      HE      N2      D2      H2     CPCALC 0710
     - 3.474, 2.912, 2.120, 2.913, 2.911, 2.079, 2.910, 3.031, 2.256,   CPCALC 0720
     - 3.474, 2.912, 2.120, 2.913, 2.911, 2.079, 2.910, 3.031, 2.256,   CPCALC 0730
     - 4.737, 2.970, 2.261, 2.913, 2.912, 2.079, 2.911, 2.920, 2.727,   CPCALC 0740
     - 6.129, 3.137, 2.274, 2.914, 2.914, 2.079, 2.912, 2.920, 2.884,   CPCALC 0750
     - 7.240, 3.305, 2.243, 2.915, 2.915, 2.079, 2.925, 2.924, 2.918,   CPCALC 0760
     - 8.071, 3.434, 2.210, 2.917, 2.916, 2.079, 2.958, 2.936, 2.926,   CPCALC 0770
     - 8.678, 3.527, 2.183, 2.923, 2.918, 2.079, 3.011, 2.962, 2.933,   CPCALC 0780
     - 9.121, 3.594, 2.163, 2.935, 2.920, 2.079, 3.075, 3.001, 2.944,   CPCALC 0790
     - 9.447, 3.646, 2.148, 2.955, 2.923, 2.079, 3.143, 3.053, 2.965,   CPCALC 0800
     - 9.693, 3.685, 2.136, 2.983, 2.926, 2.079, 3.209, 3.108, 2.991,   CPCALC 0810
     - 9.880, 3.717, 2.127, 3.017, 2.930, 2.079, 3.270, 3.164, 3.020/   CPCALC 0820
      DATA ((CP(I,J),I=1,9),J=12,21)/                                   CPCALC 0830
     -10.025, 3.744, 2.120, 3.056, 2.933, 2.079, 3.324, 3.216, 3.054,   CPCALC 0840
     -10.140, 3.767, 2.114, 3.097, 2.937, 2.079, 3.373, 3.269, 3.092,   CPCALC 0850
     -10.231, 3.787, 2.109, 3.140, 2.941, 2.079, 3.415, 3.320, 3.134,   CPCALC 0860
     -10.306, 3.804, 2.105, 3.182, 2.945, 2.079, 3.453, 3.370, 3.180,   CPCALC 0870
     -10.367, 3.820, 2.102, 3.224, 2.949, 2.079, 3.485, 3.417, 3.230,   CPCALC 0880
     -10.418, 3.835, 2.100, 3.264, 2.953, 2.079, 3.514, 3.463, 3.273,   CPCALC 0890
     -10.460, 3.848, 2.097, 3.302, 2.958, 2.079, 3.539, 3.499, 3.314,   CPCALC 0900
     -10.496, 3.861, 2.096, 3.338, 2.962, 2.079, 3.561, 3.535, 3.354,   CPCALC 0910
     -10.527, 3.874, 2.094, 3.371, 2.966, 2.079, 3.581, 3.567, 3.392,   CPCALC 0920
     -10.554, 3.886, 2.092, 3.403, 2.970, 2.079, 3.599, 3.599, 3.429/   CPCALC 0930
      DATA ((CP(I,J),I=1,9),J=22,31)/                                   CPCALC 0940
     -10.577, 3.897, 2.092, 3.433, 2.974, 2.079, 3.614, 3.626, 3.464,   CPCALC 0950
     -10.597, 3.908, 2.090, 3.460, 2.978, 2.079, 3.628, 3.653, 3.497,   CPCALC 0960
     -10.614, 3.919, 2.089, 3.486, 2.982, 2.079, 3.641, 3.678, 3.529,   CPCALC 0970
     -10.630, 3.929, 2.089, 3.510, 2.986, 2.079, 3.653, 3.702, 3.559,   CPCALC 0980
     -10.644, 3.940, 2.088, 3.532, 2.990, 2.079, 3.664, 3.724, 3.588,   CPCALC 0990
     -10.656, 3.950, 2.087, 3.553, 2.994, 2.079, 3.673, 3.745, 3.615,   CPCALC 1000
     -10.667, 3.960, 2.087, 3.573, 2.998, 2.079, 3.682, 3.764, 3.640,   CPCALC 1010
     -10.677, 3.970, 2.086, 3.592, 3.002, 2.079, 3.690, 3.783, 3.664,   CPCALC 1020
     -10.686, 3.979, 2.086, 3.609, 3.005, 2.079, 3.698, 3.799, 3.686,   CPCALC 1030
     -10.693, 3.989, 2.085, 3.625, 3.009, 2.079, 3.705, 3.815, 3.707/   CPCALC 1040
C          D      H                                                     CPCALC 1050
      DATA((CP(I,J),I=10,11),J=1,31)/62*2.079/                          CPCALC 1060
C                                                                       CPCALC 1070
      DATA RBAR/8.31434E+03/                                            CPCALC 1080
C                                                                       CPCALC 1090
      CPMIX=0.0                                                         CPCALC 1100
      MWMIX=0.0                                                         CPCALC 1110
      J=IFIX(TDZ/100.0)+1                                               CPCALC 1120
      TLO=FLOAT(J-1)*100.0                                              CPCALC 1130
      FRAC=(TDZ-TLO)/100.0                                              CPCALC 1140
      DO 101 I=NS1,NS2                                                  CPCALC 1150
      CPTDZ=1.0E+04*(FRAC*(CP(I,J+1)-CP(I,J))+CP(I,J))                  CPCALC 1160
      CPMIX=CPMIX+XF(I)*CPTDZ                                           CPCALC 1170
101   MWMIX=MWMIX+XF(I)*MW(I)                                           CPCALC 1180
      GMIX=CPMIX/(CPMIX-RBAR)                                           CPCALC 1190
```

```
      END                                                       CPCALC 1200
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```
      SUBROUTINE EXPAN(G,M1,A2A1,M2,P2P1,P20P10,T2T1,T20T10,FAIL)       EXPAN  0100
C                                                                       EXPAN  0110
C                                                                       EXPAN  0120
C***********************************************************************EXPAN  0130
C*                                                                     *EXPAN  0140
C*                ISENTROPIC EXPANSION SUBROUTINE (EXPAN)              *EXPAN  0150
C*                                                                     *EXPAN  0160
C***********************************************************************EXPAN  0170
C                                                                       EXPAN  0180
C***********************************************************************EXPAN  0190
C*                                                                     *EXPAN  0200
C*   SUBROUTINE EXPAN CALCULATES THE CONDITIONS ACROSS AN ISENTROPIC   *EXPAN  0210
C*   EXPANSION AT SUPERSONIC MACH NUMBERS.                             *EXPAN  0220
C*                                                                     *EXPAN  0230
C* INPUT VARIABLES:                                                    *EXPAN  0240
C*                                                                     *EXPAN  0250
C* G      = GAMMA                                                      *EXPAN  0260
C* M1     = ENTRANCE MACH NUMBER                                       *EXPAN  0270
C* A2A1   = EXIT-TO-ENTRANCE AREA RATIO                                *EXPAN  0280
C*                                                                     *EXPAN  0290
C* OUTPUT VARIABLES:                                                   *EXPAN  0300
C*                                                                     *EXPAN  0310
C* M2     = EXIT MACH NUMBER                                           *EXPAN  0320
C* P2P1   = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO                     *EXPAN  0330
C* P20P10 = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO                 *EXPAN  0340
C* T2T1   = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO                  *EXPAN  0350
C* T20T10 = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO              *EXPAN  0360
C* FAIL   = ERROR FLAG                                                 *EXPAN  0370
C*                                                                     *EXPAN  0380
C***********************************************************************EXPAN  0390
C                                                                       EXPAN  0400
C                                                                       EXPAN  0410
      IMPLICIT REAL(M)                                                  EXPAN  0420
      DATA YES/3HYES/,SUP/3HSUP/                                        EXPAN  0430
C                                                                       EXPAN  0440
C                                                                       EXPAN  0450
C***********************************************************************EXPAN  0460
C*                                                                     *EXPAN  0470
C*                         GAS DYNAMIC FUNCTIONS                       *EXPAN  0480
C*                                                                     *EXPAN  0490
C***********************************************************************EXPAN  0500
C                                                                       EXPAN  0510
C                                                                       EXPAN  0520
      TOTM(GX,MX)=1.0+0.5*(GX-1.0)*MX*MX                                EXPAN  0530
      POPM(GX,MX)=TOTM(GX,MX)**(GX/(GX-1.0))                            EXPAN  0540
C                                                                       EXPAN  0550
C                                                                       EXPAN  0560
C***********************************************************************EXPAN  0570
C*                                                                     *EXPAN  0580
C*                            SOLVE A2A2S FOR M2                       *EXPAN  0590
C*                                                                     *EXPAN  0600
C***********************************************************************EXPAN  0610
C                                                                       EXPAN  0620
C                                                                       EXPAN  0630
      G2=2.0/(G+1.0)                                                    EXPAN  0640
```

```
      G4=(G+1.0)/(2.0*(G-1.0))                                          EXPAN   0650
      A1A1S=(1.0/M1)*(G2*TOTM(G,M1))**G4                                EXPAN   0660
      APAPS=APA1*A1A1S                                                  EXPAN   0670
      CALL MAAS(G,M1,APAPS,SUP,5.0E-06,M2,FAIL)                         EXPAN   0680
      IF(FAIL.EQ.YES) GO TO 1                                           EXPAN   0690
C                                                                       EXPAN   0700
C                                                                       EXPAN   0710
C***********************************************************************EXPAN   0720
C*                                                                     *EXPAN   0730
C*                 CALCULATE THE PRESSURE AND TEMPERATURE RATIOS       *EXPAN   0740
C*                                                                     *EXPAN   0750
C***********************************************************************EXPAN   0760
C                                                                       EXPAN   0770
C                                                                       EXPAN   0780
      P2OP10=1.0                                                        EXPAN   0790
      T2OT10=1.0                                                        EXPAN   0800
      P2P1=POPM(G,M1)/POPM(G,M2)                                        EXPAN   0810
      T2T1=TOTM(G,M1)/TOTM(G,M2)                                        EXPAN   0820
      RETURN                                                            EXPAN   0830
C                                                                       EXPAN   0840
C                                                                       EXPAN   0850
C***********************************************************************EXPAN   0860
C*                                                                     *EXPAN   0870
C*                                  ERROR MESSAGE                      *EXPAN   0880
C*                                                                     *EXPAN   0890
C***********************************************************************EXPAN   0900
C                                                                       EXPAN   0910
C                                                                       EXPAN   0920
1     WRITE(6,2)                                                        EXPAN   0930
2     FORMAT(*0*,T2,*SUBROUTINE MAAS WAS CALLED FROM SUBROUTINE EXPAN*) EXPAN   0940
      STOP                                                              EXPAN   0950
      END                                                               EXPAN   0960
```

```
      SUBROUTINE INLDS                                                  INLDS  0100
C                                                                       INLDS  0110
C                                                                       INLDS  0120
C***********************************************************************INLDS  0130
C*                                                                     *INLDS  0140
C*                       INPUT SUBROUTINE (INLDS)                      *INLDS  0150
C*                                                                     *INLDS  0160
C***********************************************************************INLDS  0170
C                                                                       INLDS  0180
C***********************************************************************INLDS  0190
C*                                                                     *INLDS  0200
C*  SUBROUTINE INLDS CONTROLS THE INPUT OF INITIAL DATA FOR THE LASER  *INLDS  0210
C*  DEVICE SECTION.                                                    *INLDS  0220
C*                                                                     *INLDS  0230
C* INPUT/OUTPUT VARIABLES:                                             *INLDS  0240
C*                                                                     *INLDS  0250
C* BRFRAC = BANK RELIEF FRACTION                                       *INLDS  0260
C* CANGLE = CAVITY HALF-ANGLE (RAD)                                    *INLDS  0270
C* D1     = PRIMARY NOZZLE EXIT DIAMETER (M)                           *INLDS  0280
C* D1S    = D*, PRIMARY NOZZLE (M)                                     *INLDS  0290
C* D3     = SECONDARY NOZZLE EXIT DIAMETER (M)                         *INLDS  0300
C* D3S    = D*, SECONDARY NOZZLE (M)                                   *INLDS  0310
C* GEOMPN = PRIMARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:        *INLDS  0320
C*        = "AX" FOR AXISYMMETRIC NOZZLES                              *INLDS  0330
C*        = "2D" FOR SLIT NOZZLES                                      *INLDS  0340
C* GEOMSN = SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:      *INLDS  0350
C*        = "AX" FOR AXISYMMETRIC NOZZLES                              *INLDS  0360
C*        = "2D" FOR SLIT NOZZLES                                      *INLDS  0370
C* HBASE  = HEIGHT OF NOZZLE BASE (M)                                  *INLDS  0380
C* HNB    = HEIGHT OF NOZZLE BANK (M)                                  *INLDS  0390
C* LCAV   = CAVITY LENGTH (M)                                          *INLDS  0400
C* LDSS1  = CONTROL VARIABLE                                           *INLDS  0410
C* LDSS2  = CONTROL VARIABLE SUCH THAT:                                *INLDS  0420
C*        = "P10" FOR P10 AS INPUT AND T10 AS OUTPUT VARIABLES         *INLDS  0430
C*        = "T10" FOR T10 AS INPUT AND P10 AS OUTPUT VARIABLES         *INLDS  0440
C* LDSS3  = CONTROL VARIABLE                                            INLDS  0450
C* LPNOZ  = LENGTH OF PRIMARY NOZZLE (M)                               *INLDS  0460
C* LSNOZ  = LENGTH OF SECONDARY NOZZLE (M)                             *INLDS  0470
C* NSPNOZ = NUMBER OF SECONDARY-TO-PRIMARY NOZZLES                     *INLDS  0480
C* PKFRAC = NOZZLE PACKING FRACTION                                    *INLDS  0490
C* P10    = PRIMARY COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)       *INLDS  0500
C* SETLDS = CONTROL VARIABLE                                           *INLDS  0510
C* T10    = PRIMARY COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE (K)     *INLDS  0520
C* T30    = SECONDARY COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE (K)   *INLDS  0530
C* T70    = MIRROR PURGE STAGNATION TEMPERATURE (K)                    *INLDS  0540
C*                                                                     *INLDS  0550
C* NOTE: ALL INPUT IS IN SI UNITS.                                     *INLDS  0560
C*                                                                     *INLDS  0570
C***********************************************************************INLDS  0580
C                                                                       INLDS  0590
C                                                                       INLDS  0600
      IMPLICIT REAL(L,N)                                                INLDS  0610
C                                                                       INLDS  0620
      COMMON/LDS1/LDSS1                                                 INLDS  0630
C                                                                       INLDS  0640
```

```
      COMMON/LDS2/D1,D1S,D3,D3S,GEOMPN,GEOMSN,LDSS2,LPNOZ,LSNOZ,NSPNOZ,
     -PKFRAC,P10,T10,T30,T70
C
      COMMON/LDS5/BRFRAC,CANGLE,HBASE,HNB,LCAV
C
      COMMON/MAIN4/SETLDS
C
      DATA NO/2HNO/
C
      NAMELIST/NLLDS/BRFRAC,CANGLE,D1,D1S,D3,D3S,HBASE,HNB,LCAV,LPNOZ,
     -LSNOZ,NSPNOZ,PKFRAC,P10,T10,T30,T70
C
C
C***********************************************************************
C*                                                                     *
C*                         SET DEFAULT VALUES                          *
C*                                                                     *
C***********************************************************************
C
C
      IF(SETLDS.EQ.NO) GO TO 101
      BRFRAC=1.0
      CANGLE=0.174533
      D1=1.77800E-03
      D1S=6.69534E-05
      D3=1.37160E-03
      D3S=6.85800E-05
      GEOMPN=2H2D
      GEOMSN=2H2D
      HBASE=3.49250E-02
      HNB=3.49250E-02
      LCAV=7.62000E-02
      LDSS2=3HP10
      LPNOZ=2.50190E-03
      LSNOZ=1.85166E-03
      NSPNOZ=1.03846
      PKFRAC=0.803431
      P10=1.92105E+06
      T10=1.62100E+03
      T30=600.0
      T70=300.0
      SETLDS=NO
C
C
C***********************************************************************
C*                                                                     *
C*                         CONTROL STATEMENTS                          *
C*                                                                     *
C***********************************************************************
C
C
  101 WRITE(6,201)
      READ(5,202)LDSS1
      IF(LDSS1.EQ.NO) RETURN
      WRITE(6,203)
```

```
      READ(5,202)LDSS3
      IF(LDSS3.EQ.NO) GO TO 102
      REWIND 2
      READ(2)BRFRAC,CANGLE,D1,D1S,D3,D3S,GEOMPN,GEOMSN,HBASE,HNB,LCAV,
     -LDSS2,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T10,T30,T70
      RETURN
102   WRITE(6,204)
      READ(5,205)GEOMPN
      WRITE(6,206)
      READ(5,205)GEOMSN
      WRITE(6,207)
      READ(5,202)LDSS2
      WRITE(6,208)
      IF(LDSS2.EQ.3HP10) WRITE(6,209)BRFRAC,CANGLE,D1,D1S,D3,D3S,HBASE,
     -HNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T30,T70
      IF(LDSS2.EQ.3HT10) WRITE(6,210)BRFRAC,CANGLE,D1,D1S,D3,D3S,HBASE,
     -HNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,T10,T30,T70
      READ(5,NLLDS)
      REWIND 2
      WRITE(2)BRFRAC,CANGLE,D1,D1S,D3,D3S,GEOMPN,GEOMSN,HBASE,HNB,LCAV,
     -LDSS2,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T10,T30,T70
C
C
C***********************************************************************
C*                                                                    *
C*                          FORMAT STATEMENTS                         *
C*                                                                    *
C***********************************************************************
C
C
201   FORMAT(*1*,T2,*ARE NEW LASER DEVICE INPUTS REQUIRED?*,/)
202   FORMAT(A3)
203   FORMAT(*0*,T2,*SHOULD INPUT DATA BE READ FROM TAPE2?*,/)
204   FORMAT(*1*,T2,*INPUT THE LASER PRIMARY NOZZLE GEOMETRY FROM THE FO
     -LLOWING LIST:*,//,T2,*"AX" FOR AXISYMMETRIC NOZZLES*,/,T2,*"2D" FO
     -R SLIT NOZZLES*,/)
205   FORMAT(A2)
206   FORMAT(*0*,T2,*INPUT THE LASER SECONDARY NOZZLE GEOMETRY FROM THE 
     -FOLLOWING LIST:*,//,T2,*"AX" FOR AXISYMMETRIC NOZZLES*,/,T2,*"2D" 
     -FOR SLIT NOZZLES*,/)
207   FORMAT(*1*,T2,*SELECT A LASER DEVICE INPUT VARIABLE FROM THE FOLLO
     -WING LIST:*,//,T2,*"P10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGN
     -ATION PRESSURE*,/,T2,*"T10" FOR THE PRIMARY COMBUSTOR OR NOZZLE ST
     -AGNATION TEMPERATURE*,/)
208   FORMAT(*1*,T2,*INPUT DATA FOR THE LASER DEVICE SECTION BY NAMELIST
     -.*,/,T2,*CURRENT VALUES ARE:*)
209   FORMAT(* *,T2,*$NLLDS*,T26,*BRFRAC   =*,E13.6,T50,*CANGLE   =*,
     -E13.6,/,T2,*D1       =*,E13.6,T26,*D1S      =*,E13.6,T50,
     -*D3       =*,E13.6,/,T2,*D3S      =*,E13.6,T26,*HBASE    =*,E13.6,
     -T50,*HNB      =*,E13.6,/,T2,*LCAV     =*,E13.6,T26,*LPNOZ    =*,
     -E13.6,T50,*LSNOZ    =*,E13.6,/,T2,*NSPNOZ   =*,E13.6,T26,
     -*PKFRAC   =*,E13.6,T50,*P10      =*,E13.6,/,T2,*T30      =*,E13.6,
     -T26,*T70      =*,E13.6,* $*,/)
210   FORMAT(* *,T2,*$NLLDS*,T26,*BRFRAC   =*,E13.6,T50,*CANGLE   =*,
     -E13.6,/,T2,*D1       =*,E13.6,T26,*D1S      =*,E13.6,T50,
```

```
     -*D3       =*,E13.6,/,T2,*D3S      =*,E13.6,T26,*HBASF   =*,E13.6,   INLDS  1750
     -T50,*HNB      =*,E13.6,/,T2,*LCAV     =*,E13.6,T26,*LPNOZ   =*,     INLDS  1760
     -E13.6,T50,*LSNOZ   =*,E13.6,/,T2,*NSPNOZ  =*,E13.6,T26,             INLDS  1770
     -*PKFRAC  =*,E13.6,T50,*T10       =*,E13.6,/,T2,*T30      =*,E13.6,  INLDS  1780
     -T26,*T70      =*,E13.6,* $*,/)                                      INLDS  1790
      END                                                                 INLDS  1800
```

```
      SUBROUTINE ITER(X,DX,ERRORX,SIGN,Y,YGIVEN,ERRORY,NIT,
     -NTYPE,XNEG,YNEG,XPOS,YPOS,NSIGN1,NSIGN2)
C
C
C***********************************************************************
C*                                                                     *
C*                   ITERATION SUBROUTINE (ITER)                       *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C* SUBROUTINE  ITER  PERFORMS AN  ITERATION TO  FIND X SUCH  THAT  THE *
C* PERCENT  ERROR  IN Y AND  YGIVEN IS .LE. TO  ERRORY OR  THE PERCENT *
C* DEVIATION IN X(I+1) AND X(I) IS .LE. TO ERRORX.                     *
C*       IS .LE. TO ERRORX.                                            *
C*                                                                     *
C* INPUT VARIABLES:                                                    *
C*                                                                     *
C* DX     = INCREMENT IN INDEPENDENT VARIABLE                          *
C* ERRORX = MAX PERCENT DEVIATION IN X(I+1) AND X(I) FOR SOLUTION      *
C* ERRORY = MAX PERCENT ERROR IN Y AND YGIVEN FOR SOLUTION             *
C* SIGN   = +1.0 OR -1.0, +/- INCREMENTING FROM INITIAL X              *
C* Y      = DEPENDENT VARIABLE                                         *
C* YGIVEN = GIVEN VALUE OF DEPENDENT VARIABLE                          *
C*                                                                     *
C* INPUT/OUTPUT VARIABLES:                                             *
C*                                                                     *
C* NIT    = ITERATION NUMBER                                           *
C* NTYPE  = 1--INCREMENT, 2--INTERPOLATION, 3--SOLUTION                *
C* X      = INDEPENDENT VARIABLE                                       *
C*                                                                     *
C* NOTE: THE  INTERMEDIATE  VARIABLES  XNEG, YNEG, XPOS, YPOS, NSIGN1, *
C*       NSIGN2 MUST BE STORED BETWEEN ITERATIONS.                     *
C*                                                                     *
C***********************************************************************
C
C
      ERROR(ACTUAL,GIVEN)=(ACTUAL-GIVEN)*100.0/GIVEN
C
      IF(ABS(ERROR(Y,YGIVEN))-ERRORY) 90,90,10
   10 IF(Y-YGIVEN) 20,90,30
   20 NSIGN2=-1
      XNEG=X
      YNEG=Y
      GO TO 40
   30 NSIGN2=+1
      XPOS=X
      YPOS=Y
   40 GO TO (50,80), NTYPE
   50 IF(NIT-1) 70,70,60
   60 NSIGN=NSIGN1*NSIGN2
      IF(NSIGN) 80,80,70
   70 NSIGN1=NSIGN2
      NIT=NIT+1
```

```
C                                                                       ITER    0650
C                                                                       ITER    0660
C***********************************************************************ITER    0670
C*                                                                     *ITER    0680
C*                 INCREMENT TO FIND SOLUTION INTERVAL                 *ITER    0690
C*                                                                     *ITER    0700
C***********************************************************************ITER    0710
C                                                                       ITER    0720
C                                                                       ITER    0730
      X=X+SIGN*DX                                                       ITER    0740
      GO TO 100                                                         ITER    0750
C                                                                       ITER    0760
C                                                                       ITER    0770
C***********************************************************************ITER    0780
C*                                                                     *ITER    0790
C*                      INTERPOLATION FOR SOLUTION                     *ITER    0800
C*                                                                     *ITER    0810
C***********************************************************************ITER    0820
C                                                                       ITER    0830
C                                                                       ITER    0840
   80 NTYPE=2                                                           ITER    0850
      NIT=NIT+1                                                         ITER    0860
      XSAVE=X                                                           ITER    0870
      RATIO=(XPOS-XNEG)/(YPOS-YNEG)                                     ITER    0880
      X=XNEG+RATIO*(YGIVEN-YNEG)                                        ITER    0890
      IF(ABS(ERROR(X,XSAVE))-ERRORX) 90,90,100                          ITER    0900
   90 NTYPE=3                                                           ITER    0910
  100 END                                                               ITER    0920
```

```
      SUBROUTINE LBLAYR(A,B,GEOFAC,LBNOZ,MW,PE,TE,TO,VE,DELTA,RE)       LBLAYR 0100
C                                                                       LBLAYR 0110
C                                                                       LBLAYR 0120
C***********************************************************************LBLAYR 0130
C*                                                                     *LBLAYR 0140
C*                    LAMINAR BOUNDARY LAYER SUBROUTINE (LBLAYR)       *LBLAYR 0150
C*                                                                     *LBLAYR 0160
C***********************************************************************LBLAYR 0170
C                                                                       LBLAYR 0180
C***********************************************************************LBLAYR 0190
C*                                                                     *LBLAYR 0200
C* SUBROUTINE LBLAYR CALCULATES THE LAMINAR BOUNDARY LAYER THICKNESS   *LBLAYR 0210
C* AT THE EXIT OF A CONICAL NOZZLE.                                    *LBLAYR 0220
C*                                                                     *LBLAYR 0230
C* INPUT VARIABLES:                                                    *LBLAYR 0240
C*                                                                     *LBLAYR 0250
C* A      = SLOPE OF VISCOSITY-TEMPERATURE RELATION                    *LBLAYR 0260
C*          (ALOG(N-S/M2)/ALOG(K))                                     *LBLAYR 0270
C* B      = INTERSECT OF VISCOSITY-TEMPERATURE RELATION (ALOG(N-S/M2)) *LBLAYR 0280
C* GEOFAC = 0.0, FOR 2-D, PLANE NOZZLES                                *LBLAYR 0290
C*        = 1.0, FOR AXISYMMETRIC NOZZLES                              *LBLAYR 0300
C* LBNOZ  = LENGTH OF NOZZLE BOUNDARY LAYER (M)                        *LBLAYR 0310
C* MW     = MOLECULAR WEIGHT (KG/KMOLE)                                *LBLAYR 0320
C* PE     = STATIC PRESSURE AT THE NOZZLE EXIT (PA)                    *LBLAYR 0330
C* TE     = STATIC TEMPERATURE AT THE NOZZLE EXIT (K)                  *LBLAYR 0340
C* TO     = NOZZLE STAGNATION TEMPERATURE                              *LBLAYR 0350
C* VE     = VELOCITY AT THE NOZZLE EXIT (M/S)                          *LBLAYR 0360
C*                                                                     *LBLAYR 0370
C* OUTPUT VARIABLES:                                                   *LBLAYR 0380
C*                                                                     *LBLAYR 0390
C* DELTA  = BOUNDARY LAYER THICKNESS (M)                               *LBLAYR 0400
C* RE     = REYNOLDS NUMBER AT THE NOZZLE EXIT                         *LBLAYR 0410
C*                                                                     *LBLAYR 0420
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS.                   *LBLAYR 0430
C*                                                                     *LBLAYR 0440
C***********************************************************************LBLAYR 0450
C                                                                       LBLAYR 0460
C                                                                       LBLAYR 0470
      IMPLICIT REAL(L,M)                                                LBLAYR 0480
      DATA RBAR/8.31434E+03/                                            LBLAYR 0490
C                                                                       LBLAYR 0500
      MU=EXP(A*ALOG(TE)+B)                                              LBLAYR 0510
      T=TE+0.5*(0.9*TO-TE)+0.22*(TO-TE)                                 LBLAYR 0520
      RE=PE*VE*LBNOZ*MW/(RBAR*T*MU)                                     LBLAYR 0530
      DELTA=5.2*LBNOZ/(SQRT(RE)*(1.0+GEOFAC*0.732))                     LBLAYR 0540
      END                                                               LBLAYR 0550
```

```
      SUBROUTINE LCAS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MI,MR1,PR1PI,Q12,      LCAS   0100
     -TA0TR1,WA2WR1,FLOW,GM,MWMMWR,MM2,PM2PR1,PM0PR0,TM2TR1,TM0TR0,      LCAS   0110
     -XM2XR1,ZSEP)                                                       LCAS   0120
C                                                                        LCAS   0130
C                                                                        LCAS   0140
C***********************************************************************LCAS   0150
C*                                                                     *LCAS   0160
C*              LASER CAVITY ANALYSIS SUBROUTINE (LCAS)                *LCAS   0170
C*                                                                     *LCAS   0180
C***********************************************************************LCAS   0190
C                                                                        LCAS   0200
C***********************************************************************LCAS   0210
C*                                                                     *LCAS   0220
C* SUBROUTINE LCAS  IS A SIMPLIFIED FLOW MODEL TO ASSESS QUALITATIVELY *LCAS   0230
C* THE EFFECTS OF AREA CHANGE, CHEMICAL REACTION, AND MASS ADDITION ON *LCAS   0240
C* THE LASER  CAVITY FLOW.  THE FLOW MODEL IS BASED  ON THE ASSUMPTION *LCAS   0250
C* OF A  ONE-DIMENSIONAL  FLOW OF AN IDEAL, HOMOGENEOUS  GAS THROUGH A *LCAS   0260
C* CHANNEL WITH A LINEAR  VARIATION IN AREA, A RATE  OF REACTION  SUCH *LCAS   0270
C* THAT THE  HEAT RELEASE IS LINEAR  WITH THE AXIAL  COORDINATE, AND A *LCAS   0280
C* NON-REACTIVE MASS ADDITION PROPORTIONAL TO THE RATE OF REACTION.    *LCAS   0290
C*                                                                     *LCAS   0300
C* INPUT VARIABLES:                                                    *LCAS   0310
C*                                                                     *LCAS   0320
C* A2A1   = EXIT-TO-ENTRANCE AREA RATIO                                *LCAS   0330
C* GA     = GAMMA OF THE PURGE GAS                                     *LCAS   0340
C* GP     = GAMMA OF THE PRODUCT GAS                                   *LCAS   0350
C* GR     = GAMMA OF THE REACTANT GAS                                  *LCAS   0360
C* MWAMWR = PURGE-TO-REACTANT MOLECULAR WEIGHT RATIO                   *LCAS   0370
C* MWPMWR = PRODUCT-TO-REACTANT MOLECULAR WEIGHT RATIO                 *LCAS   0380
C* MI     = INITIAL MACH NUMBER FOR A ZUKOSKI SEPARATION CRITERIA      *LCAS   0390
C* MR1    = MACH NUMBER OF THE REACTANT STREAM AT THE ENTRANCE         *LCAS   0400
C* PR1PI  = REACTANT-TO-INITIAL STATIC PRESSURE RATIO                  *LCAS   0410
C* Q12    = DIMENSIONLESS HEAT RELEASE                                 *LCAS   0420
C* TA0TR1 = PURGE STAGNATION-TO-REACTANT STATIC TEMPERATURE RATIO      *LCAS   0430
C* WA2WR1 = PURGE-TO-REACTANT MASS FLOW RATIO                          *LCAS   0440
C*                                                                     *LCAS   0450
C* OUTPUT VARIABLES:                                                   *LCAS   0460
C*                                                                     *LCAS   0470
C* FLOW   = CHOKE/SEPARATION FLAG                                      *LCAS   0480
C* GM     = GAMMA OF THE MIXED STREAM                                  *LCAS   0490
C* MWMMWR = MIXED-TO-REACTANT MOLECULAR WEIGHT RATIO                   *LCAS   0500
C* MM2    = MACH NUMBER OF THE MIXED STREAM AT THE CAVITY EXIT         *LCAS   0510
C* PM2PR1 = MIXED-TO-REACTANT STATIC PRESSURE RATIO                    *LCAS   0520
C* PM0PR0 = MIXED-TO-REACTANT STAGNATION PRESSURE RATIO                *LCAS   0530
C* TM2TR1 = MIXED-TO-REACTANT STATIC TEMPERATURE RATIO                 *LCAS   0540
C* TM0TR0 = MIXED-TO-REACTANT STAGNATION TEMPERATURE RATIO             *LCAS   0550
C* XM2XR1 = MIXED-TO-REACTANT MOLAR FLOW RATIO                         *LCAS   0560
C* ZSEP   = SEPARATION LENGTH-TO-TOTAL CAVITY LENGTH RATIO             *LCAS   0570
C*                                                                     *LCAS   0580
C***********************************************************************LCAS   0590
C                                                                        LCAS   0600
C                                                                        LCAS   0610
      IMPLICIT REAL(L,M)                                                 LCAS   0620
      DIMENSION FP(3),MSQ(3),TMTR1(3),Z(3)                               LCAS   0630
      DATA CHOKE/5HCHOKE/,SEP/3HSEP/                                     LCAS   0640
```

```
C                                                                       LCAS   0650
C                                                                       LCAS   0660
C***********************************************************************LCAS   0670
C*                                                                     *LCAS   0680
C*             GAS DYNAMIC FUNCTIONS FOR ISENTROPIC FLOW               *LCAS   0690
C*                                                                     *LCAS   0700
C***********************************************************************LCAS   0710
C                                                                       LCAS   0720
C                                                                       LCAS   0730
      TOTM(GX,MX)=1.0+0.5*(GX-1.0)*MX*MX                                LCAS   0740
      POPM(GX,MX)=TOTM(GX,MX)**(GX/(GX-1.0))                            LCAS   0750
C                                                                       LCAS   0760
C                                                                       LCAS   0770
C***********************************************************************LCAS   0780
C*                                                                     *LCAS   0790
C*    CALCULATE THE SEPARATION PRESSURE RATIO FOR A ZUKOSKI CRITERIA   *LCAS   0800
C*                                                                     *LCAS   0810
C***********************************************************************LCAS   0820
C                                                                       LCAS   0830
C                                                                       LCAS   0840
      PSEPPI=1.0+0.365*MI                                               LCAS   0850
C                                                                       LCAS   0860
C                                                                       LCAS   0870
C***********************************************************************LCAS   0880
C*                                                                     *LCAS   0890
C*                DEFINE THE HEAT RELEASE COEFFICIENTS                 *LCAS   0900
C*                ASSUMING  A LINEAR  VARIATION WITH Z                 *LCAS   0910
C*                                                                     *LCAS   0920
C***********************************************************************LCAS   0930
C                                                                       LCAS   0940
C                                                                       LCAS   0950
      Q1=2.0*Q12                                                        LCAS   0960
      Q2=0.0                                                            LCAS   0970
C                                                                       LCAS   0980
C                                                                       LCAS   0990
C***********************************************************************LCAS   1000
C*                                                                     *LCAS   1010
C*              INTEGRATE D(M**2)/DZ AND DTM/DZ USING                  *LCAS   1020
C*              A  FOURTH-ORDER  RUNGE-KUTTA  FORMULA                  *LCAS   1030
C*                                                                     *LCAS   1040
C***********************************************************************LCAS   1050
C                                                                       LCAS   1060
C                                                                       LCAS   1070
      NPTS=101                                                          LCAS   1080
      DZ=1.0/FLOAT(NPTS-1)                                              LCAS   1090
      DZRKI=DZ/2.0                                                      LCAS   1100
      Z(3)=0.0                                                          LCAS   1110
      MSQ(3)=MR1*MR1                                                    LCAS   1120
      TMTR1(3)=1.0                                                      LCAS   1130
      LPMPR1=0.0                                                        LCAS   1140
      DO 105 I=2,NPTS                                                   LCAS   1150
      Z(1)=Z(3)                                                         LCAS   1160
      MSQ(1)=MSQ(3)                                                     LCAS   1170
      TMTR1(1)=TMTR1(3)                                                 LCAS   1180
      DO 106 J=1,2                                                      LCAS   1190
```

```
      N=0
      CALL LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J),Q1,Q2,TAOTR1,
     -TMTR1(J),WA2WR1,Z(J),FMSQ,FTM,DUM1,GM,MWMMWR,XMXR1)
      C1=FMSQ*DZRKI
      D1=FTM*DZRKI
      Z(J+1)=Z(J)+DZRKI/2.0
      MSQ(J+1)=MSQ(J)+C1/2.0
      TMTR1(J+1)=TMTR1(J)+D1/2.0
      GO TO 104
101   CALL LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J+1),Q1,Q2,TAOTR1,
     -TMTR1(J+1),WA2WR1,Z(J+1),FMSQ,FTM,DUM1,GM,MWMMWR,XMXR1)
      C2=FMSQ*DZRKI
      D2=FTM*DZRKI
      MSQ(J+1)=MSQ(J)+C2/2.0
      TMTR1(J+1)=TMTR1(J)+D2/2.0
      GO TO 104
102   CALL LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J+1),Q1,Q2,TAOTR1,
     -TMTR1(J+1),WA2WR1,Z(J+1),FMSQ,FTM,DUM1,GM,MWMMWR,XMXR1)
      C3=FMSQ*DZRKI
      D3=FTM*DZRKI
      Z(J+1)=Z(J)+DZRKI
      MSQ(J+1)=MSQ(J)+C3
      TMTR1(J+1)=TMTR1(J)+D3
      GO TO 104
103   CALL LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J+1),Q1,Q2,TAOTR1,
     -TMTR1(J+1),WA2WR1,Z(J+1),FMSQ,FTM,DUM1,GM,MWMMWR,XMXR1)
      C4=FMSQ*DZRKI
      D4=FTM*DZRKI
      MSQ(J+1)=MSQ(J)+(C1+2.0*(C2+C3)+C4)/6.0
      TMTR1(J+1)=TMTR1(J)+(D1+2.0*(D2+D3)+D4)/6.0
C
C
C***********************************************************************
C*                                                                     *
C*                          CHECK FOR CHOKING                          *
C*                                                                     *
C*          TRANSITIONS FROM SUBSONIC-TO-SUPERSONIC FLOW OR            *
C*          SUPERSONIC-TO-SUBSONIC  FLOW  ARE  NOT  ALLOWED            *
C*                                                                     *
C***********************************************************************
C
C
104   IF(MSQ(J).GT.1.0.AND.MSQ(J+1).GT.1.0) GO TO 105
      IF(MSQ(J).LT.1.0.AND.MSQ(J+1).LT.1.0) GO TO 105
      FLOW=CHOKE
      WRITE(6,109)
      RETURN
105   N=N+1
      GO TO (101,102,103,106),N
106   CONTINUE
C
C
C***********************************************************************
C*                                                                     *
C*              INTEGRATE D(LN(P))/DZ USING SIMPSON'S RULE             *
```

```
                                                                       *
C*                                                                     *
C***********************************************************************
C
C
      DO 107 J=1,3
107   CALL LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J),Q1,Q2,TA0TR1,
     -TMTR1(J),WA2WR1,Z(J),DUM1,DUM2,FP(J),GM,MWMMWR,XMXR1)
      LPMPR1=LPMPR1+(DZ/6.0)*(FP(1)+4.0*FP(2)+FP(3))
C
C
C***********************************************************************
C*                                                                     *
C*                       CHECK FOR FLOW SEPARATION                     *
C*                                                                     *
C***********************************************************************
C
C
      IF(FLOW.EQ.SEP) GO TO 108
      PMPI=EXP(LPMPR1)*PR1PI
      IF(PMPI.LT.PSEPPI) GO TO 108
      FLOW=SEP
      ZSEP=Z(3)
      WRITE(6,110)(ZSEP,K=1,10)
108   CONTINUE
      MM2=SQRT(MSQ(3))
      PM2PR1=EXP(LPMPR1)
      PM0PR0=P0PM(GM,MM2)*PM2PR1/P0PM(GR,MR1)
      TM2TR1=TMTR1(3)
      TM0TR0=T0TM(GM,MM2)*TM2TR1/T0TM(GR,MR1)
      XM2XR1=XMXR1
C
C
C***********************************************************************
C*                                                                     *
C*                           FORMAT STATEMENTS                         *
C*                                                                     *
C***********************************************************************
C
C
109   FORMAT(*1*,10(T2,*WARNING !!!!  THE CAVITY FLOW HAS CHOKED*,/))
110   FORMAT(*1*,10(T2,*WARNING !!!!  THE CAVITY FLOW HAS SEPARATED AT Z
     -SEP =*,E13.6,/))
      END
```

```
      SUBROUTINE LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ,Q1,Q2,TAOTR1,     LCFS   0100
     -TMTR1,WA2WR1,Z,FMSQ,FTM,FP,GM,MWMMWR,XMXR1)                       LCFS   0110
C                                                                       LCFS   0120
C                                                                       LCFS   0130
C***********************************************************************LCFS   0140
C*                                                                     *LCFS   0150
C*              LASER CAVITY FUNCTION SUBROUTINE (LCFS)                *LCFS   0160
C*                                                                     *LCFS   0170
C***********************************************************************LCFS   0180
C                                                                       LCFS   0190
C***********************************************************************LCFS   0200
C*                                                                     *LCFS   0210
C*      SUBROUTINE LCFS CALCULATES THE FUNCTIONS OF Z, M**2, AND       *LCFS   0220
C*      TMTR1 FOR THE LASER  CAVITY ANALYSIS  SUBROUTINE (LCAS).       *LCFS   0230
C*                                                                     *LCFS   0240
C* INPUT VARIABLES:                                                    *LCFS   0250
C*                                                                     *LCFS   0260
C* A2A1   = EXIT-TO-ENTRANCE AREA RATIO                                *LCFS   0270
C* GA     = GAMMA OF THE PURGE GAS                                     *LCFS   0280
C* GP     = GAMMA OF THE PRODUCT GAS                                   *LCFS   0290
C* GR     = GAMMA OF THE REACTANT GAS                                  *LCFS   0300
C* MWAMWR = PURGE-TO-REACTANT MOLECULAR WEIGHT RATIO                   *LCFS   0310
C* MWPMWR = PRODUCT-TO-REACTANT MOLECULAR WEIGHT RATIO                 *LCFS   0320
C* MSQ    = (MIXED STREAM MACH NUMBER)**2                              *LCFS   0330
C* Q1     = HEAT RELEASE COEFFICIENT                                   *LCFS   0340
C* Q2     = HEAT RELEASE COEFFICIENT                                   *LCFS   0350
C* TAOTR1 = PURGE STAGNATION-TO-REACTANT STATIC TEMPERATURE RATIO      *LCFS   0360
C* TMTR1  = MIXED-TO-REACTANT STATIC TEMPERATURE RATIO                 *LCFS   0370
C* WA2WR1 = PURGE-TO-REACTANT MASS FLOW RATIO                          *LCFS   0380
C* Z      = DIMENSIONLESS AXIAL COORDINATE                             *LCFS   0390
C*                                                                     *LCFS   0400
C* OUTPUT VARIABLES:                                                   *LCFS   0410
C*                                                                     *LCFS   0420
C* FMSQ   = D(M**2)/DZ                                                 *LCFS   0430
C* FP     = D(LN(P))/DZ                                                *LCFS   0440
C* FTM    = DTM/DZ                                                     *LCFS   0450
C* GM     = GAMMA OF THE MIXED STREAM                                  *LCFS   0460
C* MWMMWR = MIXED-TO-REACTANT MOLECULAR WEIGHT RATIO                   *LCFS   0470
C* XMXR1  = MIXED-TO-REACTANT MOLAR FLOW RATIO                         *LCFS   0480
C*                                                                     *LCFS   0490
C***********************************************************************LCFS   0500
C                                                                       LCFS   0510
C                                                                       LCFS   0520
      IMPLICIT REAL(M)                                                  LCFS   0530
C                                                                       LCFS   0540
C                                                                       LCFS   0550
C***********************************************************************LCFS   0560
C*                                                                     *LCFS   0570
C*                             FUNCTION STATEMENTS                     *LCFS   0580
C*                                                                     *LCFS   0590
C***********************************************************************LCFS   0600
C                                                                       LCFS   0610
C                                                                       LCFS   0620
      GFUNC1(A,B,C)=F2*A+(B+WA2WR1*C)*F3                                LCFS   0630
      GFUNC2(A,B,C)=(A+WA2WR1*B-C)*F1                                   LCFS   0640
```

```
C
C
C***********************************************************************
C*                                                                     *
C*                          CALCULATE CONSTANTS                        *
C*                                                                     *
C***********************************************************************
C
C
      GA1=GA/(GA-1.0)
      GA2=1.0/(GA-1.0)
      GP1=GP/(GP-1.0)
      GP2=1.0/(GP-1.0)
      GR1=GR/(GR-1.0)
      GR2=1.0/(GR-1.0)
      MWRMWA=1.0/MWAMWR
      MWRMWP=1.0/MWPMWR
C
C
C***********************************************************************
C*                                                                     *
C*                               FUNCTIONS OF Z                        *
C*                                                                     *
C***********************************************************************
C
C
      F1=2.0*((Q2-Q1)*Z+Q1)/(Q2+Q1)
      F2=(((Q1-Q2)*Z-2.0*Q1)*Z+(Q2+Q1))/(Q2+Q1)
      F3=(((Q2-Q1)*Z+2.0*Q1)*Z)/(Q2+Q1)
      GM=GFUNC1(GR1,MWRMWP*GP1,MWRMWA*GA1)/GFUNC1(GR2,MWRMWP*GP2,
     -MWRMWA*GA2)
      MWMMWR=GFUNC1(1.0,1.0,1.0)/GFUNC1(1.0,MWRMWP,MWRMWA)
      Q=(Q2-Q1)*Z+Q1
      XMXR1=GFUNC1(1.0,MWRMWP,MWRMWA)
C
C
C***********************************************************************
C*                                                                     *
C*                      FUNCTIONS OF Z, MSQ, AND TMTR1                 *
C*                                                                     *
C*         FA   = (1/A)(DA/DZ)             FGM  = (1/GM)(DGM/Z)        *
C*         FH   = (1/CPM*TM)(DH/DZ)        FMWM = (1/MWM)(DMWM/DZ)     *
C*         FMSQ = D(M**2)/DZ               FP   = D(LN(P))/DZ          *
C*         FTM  = DTM/DZ                   FXM  = (1/XM)(DXM/DZ)       *
C*                                                                     *
C***********************************************************************
C
C
      FA=(A2A1-1.0)/((A2A1-1.0)*Z+1.0)
      FGM=GFUNC2(MWRMWP*GP1,MWRMWA*GA1,GR1)/GFUNC1(GR1,MWRMWP*GP1,
     -MWRMWA*GA1)-GFUNC2(MWRMWP*GP2,MWRMWA*GA2,GR2)/GFUNC1(GR2,MWRMWP*
     -GP2,MWRMWA*GA2)
      FH=((GM-1.0)/GM)*(GR1*Q/TMTR1-(GA1*MWRMWA*(1.0-TAOTR1/TMTR1)+
     -MSQ*GM/(2.0*MWMMWR))*WA2WR1*F1)/XMXR1
      FMWM=GFUNC2(0.0,1.0,0.0)/GFUNC1(1.0,1.0,1.0)-GFUNC2(MWRMWP,MWRMWA,
```

```
     -1.0)/GFUNC1(1.0,MWRMWP,MWRMWA)                                      LCFS   1200
      FXM=GFUNC2(MWRMWP,MWRMWA,1.0)/GFUNC1(1.0,MWRMWP,MWRMWA)             LCFS   1210
      FMSQ=MSQ*((2.0+(GM-1.0)*MSQ)*((1.0+GM*MSQ)*(FXM+FMWM)-FA)+(1.0+     LCFS   1220
     -GM*MSQ)*(FM-FMWM)-FGM)/(1.0-MSQ)                                    LCFS   1230
      FP=GM*MSQ*(FA-FM+FMWM-(2.0+(GM-1.0)*MSQ)*(FMWM+FXM))/(1.0-MSQ)      LCFS   1240
      FTM=TMTR1*((GM-1.0)*MSQ*(FA-(1.0+GM*MSQ)*(FXM+FMWM)+FMWM)+(1.0-GM*LCFS   1250
     -MSQ)*FM)/(1.0-MSQ)                                                  LCFS   1260
      END                                                                 LCFS   1270
```

```
      SUBROUTINE LPNCS(DPE,DPS,DSE,GEOMPN,GEOMSN,HNB,LDSS2,LPNOZ,NSPNOZ,LPNCS  0100
     -PKFRAC,P0,T0,AEASE,AEASO,AKMSC,AKMSE,AKMST,FAIL,GC,GE,ME,MW,NPNOZ,LPNCS  0110
     -PE,RE,TS)                                                         LPNCS  0120
C                                                                       LPNCS  0130
C                                                                       LPNCS  0140
C***********************************************************************LPNCS  0150
C*                                                                     *LPNCS  0160
C*          LASER PRIMARY NOZZLE CALCULATION SUBROUTINE (LPNCS)        *LPNCS  0170
C*                                                                     *LPNCS  0180
C***********************************************************************LPNCS  0190
C                                                                       LPNCS  0200
C***********************************************************************LPNCS  0210
C*                                                                     *LPNCS  0220
C*  GIVEN A LASER NOZZLE CONFIGURATION AND PRIMARY COMBUSTOR PRESSURE  *LPNCS  0230
C*  (TEMPERATURE), SUBROUTINE LPNCS CALCULATES THE PRIMARY  COMBUSTOR  *LPNCS  0240
C*  TEMPERATURE (PRESSURE)  REQUIRED  TO  ACHIEVE A  GIVEN  AVALIABLE  *LPNCS  0250
C*  FLUORINE FLUX.                                                     *LPNCS  0260
C*                                                                     *LPNCS  0270
C* INPUT VARIABLES:                                                    *LPNCS  0280
C*                                                                     *LPNCS  0290
C* DFORHF = CONTROL VARIABLE SUCH THAT:                                *LPNCS  0300
C*        = "DF" FOR A DF CHEMICAL LASER                               *LPNCS  0310
C*        = "HF" FOR A HF CHEMICAL LASER                               *LPNCS  0320
C* DPE    = PRIMARY NOZZLE EXIT DIAMETER (M)                           *LPNCS  0330
C* DPS    = D*, PRIMARY NOZZLE (M)                                     *LPNCS  0340
C* DSE    = SECONDARY NOZZLE EXIT DIAMETER (M)                         *LPNCS  0350
C* FOAA   = FREE FLOURINE FLUX (KMOLE/S-M2)                            *LPNCS  0360
C* GEOMPN = PRIMARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:        *LPNCS  0370
C*        = "AX" FOR AXISYMMETRIC NOZZLES                              *LPNCS  0380
C*        = "2D" FOR SLIT NOZZLES                                      *LPNCS  0390
C* GEOMSN = SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:      *LPNCS  0400
C*        = "AX" FOR AXISYMMETRIC NOZZLES                              *LPNCS  0410
C*        = "2D" FOR SLIT NOZZLES                                      *LPNCS  0420
C* HNB    = HEIGHT OF NOZZLE BANK (M)                                  *LPNCS  0430
C* LPNOZ  = LENGTH OF PRIMARY NOZZLE (M)                               *LPNCS  0440
C* NSPNOZ = NUMBER OF SECONDARY-TO-PRIMARY NOZZLES                     *LPNCS  0450
C* PKFRAC = NOZZLE PACKING FRACTION                                    *LPNCS  0460
C* XFPP1  = MOLE FRACTION OF CF4                                       *LPNCS  0470
C* XFPP2  = MOLE FRACTION OF F2                                        *LPNCS  0480
C* XFPP3  = MOLE FRACTION OF F                                         *LPNCS  0490
C* XFPP4  = MOLE FRACTION OF HF                                        *LPNCS  0500
C* XFPP5  = MOLE FRACTION OF HE                                        *LPNCS  0510
C* XFPP6  = MOLE FRACTION OF N2                                        *LPNCS  0520
C*                                                                     *LPNCS  0530
C* INPUT/OUTPUT VARIABLES:                                             *LPNCS  0540
C*                                                                     *LPNCS  0550
C* LDSS2  = CONTROL VARIABLE SUCH THAT:                                *LPNCS  0560
C*        = "PIO" FOR P0 AS INPUT AND T0 AS OUTPUT VARIABLES           *LPNCS  0570
C*        = "TIO" FOR T0 AS INPUT AND P0 AS OUTPUT VARIABLES           *LPNCS  0580
C* P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)               *LPNCS  0590
C* T0     = COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE (K)             *LPNCS  0600
C*                                                                     *LPNCS  0610
C* OUTPUT VARIABLES:                                                   *LPNCS  0620
C*                                                                     *LPNCS  0630
C* AEASE  = A/A*, EFFECTIVE                                            *LPNCS  0640
```

```
C* AEASG  = A/A*, GEOMETRIC                                            *LPNCS  0650
C* AKMSC  = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW PER      *LPNCS  0660
C*          KMOLE/S OF PRIMARY FLOW BASED ON THE COMBUSTOR TEMPERATURE *LPNCS  0670
C*          (S-M2/KMOLE)                                               *LPNCS  0680
C* AKMSE  = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW PER      *LPNCS  0690
C*          KMOLE/S OF PRIMARY FLOW BASED ON THE EXIT TEMPERATURE      *LPNCS  0700
C*          (S-M2/KMOLE)                                               *LPNCS  0710
C* AKMST  = TOTAL AREA OF NOZZLE BANK PER KMOLE/S OF PRIMARY FLOW      *LPNCS  0720
C*          BASED ON THE EXIT TEMPERATURE (S-M2/KMOLE)                 *LPNCS  0730
C* FAIL   = ERROR FLAG                                                 *LPNCS  0740
C* GC     = GAMMA OF THE PRIMARY STREAM BASED ON THE COMBUSTOR         *LPNCS  0750
C*          TEMPERATURE                                                *LPNCS  0760
C* GE     = GAMMA OF THE PRIMARY STREAM BASED ON THE EXIT TEMPERATURE  *LPNCS  0770
C* ME     = MACH NUMBER AT THE NOZZLE EXIT                             *LPNCS  0780
C* MW     = MOLECULAR WEIGHT OF THE PRIMARY STREAM (KG/KMOLE)          *LPNCS  0790
C* NPNOZ  = NUMBER OF PRIMARY NOZZLES PER KMOLE/S OF PRIMARY FLOW      *LPNCS  0800
C*          (S/KMOLE)                                                  *LPNCS  0810
C* PE     = STATIC PRESSURE AT THE NOZZLE EXIT (PA)                    *LPNCS  0820
C* RE     = REYNOLDS NUMBER AT THE NOZZLE EXIT                         *LPNCS  0830
C* TE     = STATIC TEMPERATURE AT THE NOZZLE EXIT (K)                  *LPNCS  0840
C*                                                                     *LPNCS  0850
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS                    *LPNCS  0860
C*                                                                     *LPNCS  0870
C***********************************************************************LPNCS  0880
C                                                                       LPNCS  0890
C                                                                       LPNCS  0900
      IMPLICIT REAL(M)                                                  LPNCS  0910
      REAL LBNOZ,LPNOZ,NSPNOZ,NPNOZ                                     LPNCS  0920
C                                                                       LPNCS  0930
      DIMENSION XF(11)                                                  LPNCS  0940
C                                                                       LPNCS  0950
      COMMON/CCS3/DFORMF                                                LPNCS  0960
      COMMON/CCS4/FDAA                                                  LPNCS  0970
      COMMON/CCS13/XFPP1,XFPP4,XFPP5,XFPP6                              LPNCS  0980
      COMMON/CCS14/XFPP2                                                LPNCS  0990
      COMMON/CCS15/XFPP3                                                LPNCS  1000
C                                                                       LPNCS  1010
      DATA PI/3.14159265358979/,RBAR/8.31434E+03/                       LPNCS  1020
      DATA AX/2HAX/,MF/2HMF/,SUP/3HSUP/,YES/3HYES/                      LPNCS  1030
C                                                                       LPNCS  1040
C                                                                       LPNCS  1050
C***********************************************************************LPNCS  1060
C*                                                                     *LPNCS  1070
C*                           FUNCTION STATEMENTS                       *LPNCS  1080
C*                                                                     *LPNCS  1090
C***********************************************************************LPNCS  1100
C                                                                       LPNCS  1110
C                                                                       LPNCS  1120
      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M                                     LPNCS  1130
      POPM(G,M)=TOTM(G,M)**(G/(G-1.0))                                  LPNCS  1140
      WA(G,M)=M*SQRT(G*TOTM(G,M))                                       LPNCS  1150
      AASM(G,M)=(1.0/M)*(2.0*TOTM(G,M)/(G+1.0))**(0.5*(G+1.0)/(G-1.0))  LPNCS  1160
C                                                                       LPNCS  1170
C                                                                       LPNCS  1180
C***********************************************************************LPNCS  1190
```

```
                                                                       *
C*
C*                  CALCULATE THE  PRIMARY STREAM VISCOSITY            *
C*                  COEFFICIENTS AND MOLECULAR WEIGHT RATIO            *
C*                                                                     *
C***********************************************************************
C
C
      XF(1)=XFPP1
      XF(2)=XFPP2
      XF(3)=XFPP3
      XF(6)=XFPP5
      XF(7)=XFPP6
      IF(DFORMF.EQ.MF) GO TO 101
      XF(4)=XFPP4
      XF(5)=0.0
      GO TO 102
101   XF(4)=0.0
      XF(5)=XFPP4
102   CALL VISC(1,7,XF,A,B)
      CALL CPCALC(1,7,TO,XF,GC,MW)
C
C
C***********************************************************************
C*                                                                     *
C*                     NOZZLE GEOMETRY CALCULATIONS                    *
C*                                                                     *
C***********************************************************************
C
C
      IF(GEOMPN.NE.AX) GO TO 103
      GEOFAC=1.0
      AEASG=DPE*DPE/(DPS*DPS)
      AS=PI*DPS*DPS/4.0
      C1=DPE*DPE*PI/4.0
      GO TO 104
103   GEOFAC=0.0
      AEASG=DPE/DPS
      AS=DPS*HNB
      C1=DPE*HNB
104   LBNOZ=SQRT(LPNOZ*LPNOZ+((DPE-DPS)/2.0)**2)
      IF(GEOMSN.EQ.AX) AFAC=(C1+DSE*DSE*NSPNOZ*PI/4.0)/PKFRAC
      IF(GEOMSN.NE.AX) AFAC=(C1+DSE*HNB*NSPNOZ)/PKFRAC
C
C
C***********************************************************************
C*                                                                     *
C*                   CALCULATE THE PRIMARY FLOW RATES                  *
C*                                                                     *
C***********************************************************************
C
C
      AKMST=XFPP3/FDAA
      NPNOZ=AKMST/AFAC
      XP=1.0/NPNOZ
      WP=XP*MW
```

```
C
C
C***********************************************************************
C*                                                                     *
C*                   ITERATE TO TO FIND XPO=PO                         *
C*                                                                     *
C***********************************************************************
C
C
      IF(LOSS2.EQ.3HT10) GO TO 106
      NTYPE=1
      NIT=1
      TO=100.0
      DO 105 ITER1=1,100
      CALL CPCALC(1,7,TO,XF,GC,MW)
      PS=WP*SQRT(RBAR*TO/MW)/(AS*WM(GC,1.0))
      XPO=PS*POPM(GC,1.0)
      CALL ITER(TO,2900.0,5.0E-06,+1.0,XPO,PO,5.0E-06,NIT,NTYPE,XNEG,
     -YNEG,XPOS,YPOS,NSIGN1,NSIGN2)
      IF(NTYPE.EQ.3) GO TO 107
      IF(TO.GT.3000.0) GO TO 111
105   CONTINUE
      GO TO 113
106   PS=WP*SQRT(RBAR*TO/MW)/(AS*WM(GC,1.0))
      PO=PS*POPM(GC,1.0)
C
C
C***********************************************************************
C*                                                                     *
C*          ITERATE ME TO ESTABLISH THE NOZZLE EXIT CONDITIONS         *
C*                                                                     *
C***********************************************************************
C
C
107   NTYPE=1
      NIT=1
      CALL MAAS(GC,1.0,AEASQ,SUP,5.0E-06,MSUPD,FAIL)
      IF(FAIL.EQ.YES) GO TO 110
      DELME=MSUPD-1.0
      ME=MSUPD
      DO 108 ITER1=1,100
      AEASE=AASM(GC,ME)
      PE=PO/POPM(GC,ME)
      TE=TO/TOTM(GC,ME)
      VE=ME*SQRT(GC*RBAR*TE/MW)
      CALL LBLAYR(A,B,GEOFAC,LBNOZ,MW,PE,TE,TO,VE,DELTA,RE)
      DPFE=DPE-2.0*DELTA
      XAEASE=DPFE/DPS
      IF(GEOMPN.EQ.AX) XAEASE=XAEASE*XAEASE
      SIGMA=AEASE-XAEASE+1.0
      ERROR=AEASE*5.0E-06
      CALL ITER(ME,DELME,5.0E-06,-1.0,SIGMA,1.0,ERROR,NIT,NTYPE,XNEG,
     -YNEG,XPOS,YPOS,NSIGN1,NSIGN2)
      IF(NTYPE.EQ.3) GO TO 109
      IF(ME.LT.1.0.OR.ME.GT.MSUPD) GO TO 112
```

```
108   CONTINUE                                                          LPNCS  2300
      GO TO 114                                                         LPNCS  2310
109   AEF=AEASE*A3                                                      LPNCS  2320
C                                                                       LPNCS  2330
C                                                                       LPNCS  2340
C***********************************************************************LPNCS  2350
C*                                                                     *LPNCS  2360
C*                 RECALCULATE THE PRIMARY STREAM PROPERTIES           *LPNCS  2370
C*                 BASED  ON  THE  NOZZLE  EXIT  TEMPERATURE           *LPNCS  2380
C*                                                                     *LPNCS  2390
C***********************************************************************LPNCS  2400
C                                                                       LPNCS  2410
C                                                                       LPNCS  2420
      CALL CPCALC(1,7,TE,XE,GE,MW)                                      LPNCS  2430
C                                                                       LPNCS  2440
C                                                                       LPNCS  2450
C***********************************************************************LPNCS  2460
C*                                                                     *LPNCS  2470
C*   CALCULATE THE TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW   *LPNCS  2480
C*                                                                     *LPNCS  2490
C***********************************************************************LPNCS  2500
C                                                                       LPNCS  2510
C                                                                       LPNCS  2520
      AKMSC=AEF*NPNOZ                                                   LPNCS  2530
      AKMSE=AKMSC*WM(GC,ME)/WM(GE,ME)                                   LPNCS  2540
      RETURN                                                            LPNCS  2550
C                                                                       LPNCS  2560
C                                                                       LPNCS  2570
C***********************************************************************LPNCS  2580
C*                                                                     *LPNCS  2590
C*                           FAILURE INDICATORS                        *LPNCS  2600
C*                                                                     *LPNCS  2610
C***********************************************************************LPNCS  2620
C                                                                       LPNCS  2630
C                                                                       LPNCS  2640
110   WRITE(6,201)                                                      LPNCS  2650
      RETURN                                                            LPNCS  2660
111   WRITE(6,202)                                                      LPNCS  2670
      GO TO 115                                                         LPNCS  2680
112   WRITE(6,203)                                                      LPNCS  2690
      GO TO 115                                                         LPNCS  2700
113   WRITE(6,204)                                                      LPNCS  2710
      GO TO 115                                                         LPNCS  2720
114   WRITE(6,205)                                                      LPNCS  2730
115   WRITE(6,206)A,B,GC,MW,ME,MSUPD,RE,WP,TE,T0,PE,PS,XP0,P0,XAEASE,   LPNCS  2740
     -AEASE                                                             LPNCS  2750
      FAIL=YES                                                          LPNCS  2760
C                                                                       LPNCS  2770
C                                                                       LPNCS  2780
C***********************************************************************LPNCS  2790
                                                                       *LPNCS  2800
C*                           FORMAT STATEMENTS                         *LPNCS  2810
C*                                                                     *LPNCS  2820
C***********************************************************************LPNCS  2830
C                                                                       LPNCS  2840
```

```
C                                                                         LPNCS  2850
201   FORMAT(*0*,T2,*SUBROUTINE MAAS WAS CALLED FROM SUBROUTINE*,/,T2,  LPNCS  2860
     -*LPNCS FOR THE CALCULATION OF MSUPD FROM AFASE*)                   LPNCS  2870
202   FORMAT(*1*,T2,*T0 HAS EXCEEDED THE LIMITS OF SUBROUTINE CPCALC*,/,LPNCS  2880
     -T2,*PROGRAM TERMINATED IN SUBROUTINE LPNCS*)                       LPNCS  2890
203   FORMAT(*1*,T2,*IMPOSSIBLE VALUE FOR MF*,/,T2,*PROGRAM TERMINATED ILPNCS  2900
     -N SUBROUTINE LPNCS*)                                               LPNCS  2910
204   FORMAT(*1*,T2,*CONVERGENCE FAILURE IN SUBROUTINE LPNCS FOR T0 SUCHLPNCS  2920
     - THAT XP0=P0*)                                                     LPNCS  2930
205   FORMAT(*1*,T2,*CONVERGENCE FAILURE IN SUBROUTINE LPNCS FOR MF SUCHLPNCS  2940
     - THAT XAFASE=AFASE*)                                               LPNCS  2950
206   FORMAT(*0*,T2,*A      =*,F13.6,T38,*R      =*,F13.6,/,             LPNCS  2960
     -T2,*CC     =*,F13.6,T38,*MW     =*,F13.6,* KG/KMOLE*,/,           LPNCS  2970
     -T2,*MF     =*,F13.6,T38,*MSUPD  =*,F13.6,/,                        LPNCS  2980
     -T2,*MT     =*,F13.6,T38,*MP     =*,F13.6,* KG/S*,/,                LPNCS  2990
     -T2,*TF     =*,F13.6,* K*,T38,*T0     =*,F13.6,* K*,/,              LPNCS  3000
     -T2,*PF     =*,F13.6,* PA*,T38,*PS     =*,F13.6,* PA*,/,            LPNCS  3010
     -T2,*XP0    =*,F13.6,* PA*,T38,*P0     =*,F13.6,* PA*,/,            LPNCS  3020
     -T2,*XAFASE =*,F13.6,T38,*AFASE  =*,F13.6)                          LPNCS  3030
      END                                                                LPNCS  3040
```

```
      SUBROUTINE LSNCS1(DE,DS,GEOMSN,HNB,LSNOZ,NPNOZ,NSPNOZ,TO,AEASE,   LSNCS1 0100
     -AEASG,AKNSC,AKNSE,FAIL,GC,GE,ME,MW,NSNOZ,PE,PO,RE,TE,XKMS)        LSNCS1 0110
C                                                                       LSNCS1 0120
C                                                                       LSNCS1 0130
C***********************************************************************LSNCS1 0140
C*                                                                     *LSNCS1 0150
C*        LASER SECONDARY NOZZLE CALCULATION SUBROUTINE (LSNCS1)       *LSNCS1 0160
C*                                                                     *LSNCS1 0170
C***********************************************************************LSNCS1 0180
C                                                                       LSNCS1 0190
C***********************************************************************LSNCS1 0200
C*                                                                     *LSNCS1 0210
C* GIVEN A CONVERGING-DIVERGING LASER NOZZLE CONFIGURATION, SUBROUTINE *LSNCS1 0220
C* LSNCS1  CALCULATES THE SECONDARY  COMBUSTOR OR STAGNATION  PRESSURE *LSNCS1 0230
C* REQUIRED TO ACHIEVE A GIVEN LASER CAVITY MIXTURE RATIO.            *LSNCS1 0240
C*                                                                     *LSNCS1 0250
C* INPUT VARIABLES:                                                    *LSNCS1 0260
C*                                                                     *LSNCS1 0270
C* DFORHF = CONTROL VARIABLE SUCH THAT:                                *LSNCS1 0280
C*        = "DF" FOR A DF CHEMICAL LASER                               *LSNCS1 0290
C*        = "HF" FOR A HF CHEMICAL LASER                               *LSNCS1 0300
C* DE     = SECONDARY NOZZLE EXIT DIAMETER (M)                         *LSNCS1 0310
C* DS     = D* (M)                                                     *LSNCS1 0320
C* GEOMSN = SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:      *LSNCS1 0330
C*        = "AX" FOR AXISYMMETRIC NOZZLES                              *LSNCS1 0340
C*        = "2D" FOR SLIT NOZZLES                                      *LSNCS1 0350
C* HNB    = HEIGHT OF NOZZLE BANK (M)                                  *LSNCS1 0360
C* LSNOZ  = LENGTH OF SECONDARY NOZZLE (M)                             *LSNCS1 0370
C* NPNOZ  = NUMBER OF PRIMARY NOZZLES PER KMOLE/S OF PRIMARY FLOW      *LSNCS1 0380
C*            (S/KMOLE)                                                *LSNCS1 0390
C* NSPNOZ = NUMBER OF SECONDARY-TO-PRIMARY NOZZLES                     *LSNCS1 0400
C* RL     = LASER CAVITY MIXTURE RATIO                                 *LSNCS1 0410
C* TO     = COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE (K)             *LSNCS1 0420
C* XFPP2   = MOLE FRACTION OF F2 IN PRIMARY STREAM                     *LSNCS1 0430
C* XFPP3   = MOLE FRACTION OF F IN PRIMARY STREAM                      *LSNCS1 0440
C* XFSP1  = MOLE FRACTION OF D2 IN SECONDARY STREAM                    *LSNCS1 0450
C* XFSP2  = MOLE FRACTION OF HE IN SECONDARY STREAM                    *LSNCS1 0460
C* XFSP3  = MOLE FRACTION OF N2 IN SECONDARY STREAM                    *LSNCS1 0470
C*                                                                     *LSNCS1 0480
C* OUTPUT VARIABLES:                                                   *LSNCS1 0490
C*                                                                     *LSNCS1 0500
C* AEASE  = A/A*, EFFECTIVE                                            *LSNCS1 0510
C* AEASG  = A/A*, GEOMETRIC                                            *LSNCS1 0520
C* AKNSC  = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR SECONDARY FLOW PER    *LSNCS1 0530
C*          KMOLE/S OF PRIMARY FLOW BASED ON THE COMBUSTOR TEMPERATURE *LSNCS1 0540
C*          (S-M2/KMOLE)                                               *LSNCS1 0550
C* AKNSE  = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR SECONDARY FLOW PER    *LSNCS1 0560
C*          KMOLE/S OF PRIMARY FLOW BASED ON THE EXIT TEMPERATURE      *LSNCS1 0570
C*          (S-M2/KMOLE)                                               *LSNCS1 0580
C* FAIL   = ERROR FLAG                                                 *LSNCS1 0590
C* GC     = GAMMA OF THE SECONDARY STREAM BASED ON THE COMBUSTOR       *LSNCS1 0600
C*          TEMPERATURE                                                *LSNCS1 0610
C* GE     = GAMMA OF THE SECONDARY STREAM BASED ON THE EXIT            *LSNCS1 0620
C*          TEMPERATURE                                                *LSNCS1 0630
C* ME     = MACH NUMBER AT THE NOZZLE EXIT                             *LSNCS1 0640
```

```
C* MW      = MOLECULAR WEIGHT OF THE SECONDARY STREAM (KG/KMOLE)      *LSNCS1 0650
C* NSNOZ   = NUMBER OF SECONDARY NOZZLES PER KMOLE/S OF PRIMARY FLOW  *LSNCS1 0660
C*           (S/KMOLE)                                                 *LSNCS1 0670
C* PE      = STATIC PRESSURE AT THE NOZZLE EXIT (PA)                   *LSNCS1 0680
C* PO      = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)              *LSNCS1 0690
C* RE      = REYNOLDS NUMBER AT THE NOZZLE EXIT                        *LSNCS1 0700
C* TE      = STATIC TEMPERATURE AT THE NOZZLE EXIT (K)                 *LSNCS1 0710
C* XKMS    = TOTAL SECONDARY MOLAR FLOW RATE PER KMOLE/S OF PRIMARY    *LSNCS1 0720
C*           FLOW                                                      *LSNCS1 0730
C*                                                                     *LSNCS1 0740
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS                    *LSNCS1 0750
C*                                                                     *LSNCS1 0760
C***********************************************************************LSNCS1 0770
C                                                                       LSNCS1 0780
C                                                                       LSNCS1 0790
      IMPLICIT REAL(M)                                                  LSNCS1 0800
      REAL LBNOZ,LSNOZ,NPNOZ,NSNOZ,NSPNOZ                               LSNCS1 0810
C                                                                       LSNCS1 0820
      DIMENSION XF(11)                                                  LSNCS1 0830
C                                                                       LSNCS1 0840
      COMMON/CCS3/DFORHF                                                LSNCS1 0850
      COMMON/CCS8/RL                                                    LSNCS1 0860
      COMMON/CCS14/XFPP2                                                LSNCS1 0870
      COMMON/CCS15/XFPP3                                                LSNCS1 0880
      COMMON/CCS16/XFSR1,XFSR2,XFSR3                                    LSNCS1 0890
C                                                                       LSNCS1 0900
      DATA PI/3.14159265358979/,RBAR/8.31434E+03/                       LSNCS1 0910
      DATA AX/2HAX/,HF/2HHF/,SUP/3HSUP/,YES/3HYES/                      LSNCS1 0920
C                                                                       LSNCS1 0930
C                                                                       LSNCS1 0940
C***********************************************************************LSNCS1 0950
C*                                                                     *LSNCS1 0960
C*                           FUNCTION STATEMENTS                       *LSNCS1 0970
C*                                                                     *LSNCS1 0980
C***********************************************************************LSNCS1 0990
C                                                                       LSNCS1 1000
C                                                                       LSNCS1 1010
      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M                                     LSNCS1 1020
      POPM(G,M)=TOTM(G,M)**(G/(G-1.0))                                  LSNCS1 1030
      WM(G,M)=M*SQRT(G*TOTM(G,M))                                       LSNCS1 1040
      AASM(G,M)=(1.0/M)*(2.0*TOTM(G,M)/(G+1.0))**(0.5*(G+1.0)/(G-1.0))  LSNCS1 1050
C                                                                       LSNCS1 1060
C                                                                       LSNCS1 1070
C***********************************************************************LSNCS1 1080
C*                                                                     *LSNCS1 1090
C*                 CALCULATE THE SECONDARY STREAM PROPERTIES           *LSNCS1 1100
C*                    BASED ON THE  COMBUSTOR TEMPERATURE              *LSNCS1 1110
C*                                                                     *LSNCS1 1120
C***********************************************************************LSNCS1 1130
C                                                                       LSNCS1 1140
C                                                                       LSNCS1 1150
      XF(6)=XFSR2                                                       LSNCS1 1160
      XF(7)=XFSR3                                                       LSNCS1 1170
      IF(DFORHF.EQ.HF) GO TO 101                                        LSNCS1 1180
      XF(8)=XFSR1                                                       LSNCS1 1190
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      XF(9)=0.0                                                         LSNCS1 1200
      GO TO 102                                                         LSNCS1 1210
101   XF(8)=0.0                                                         LSNCS1 1220
      XF(4)=XFSR1                                                       LSNCS1 1230
102   CALL VISC(6,9,XF,A,B)                                             LSNCS1 1240
      CALL CPCALC(6,9,T0,XF,GC,MW)                                      LSNCS1 1250
C                                                                       LSNCS1 1260
C                                                                       LSNCS1 1270
C***********************************************************************LSNCS1 1280
C*                                                                     *LSNCS1 1290
C*                     NOZZLE GEOMETRY CALCULATIONS                    *LSNCS1 1300
C*                                                                     *LSNCS1 1310
C***********************************************************************LSNCS1 1320
C                                                                       LSNCS1 1330
C                                                                       LSNCS1 1340
      IF(GEOMSN.NE.AX) GO TO 103                                        LSNCS1 1350
      GEOFAC=1.0                                                        LSNCS1 1360
      AEASG=DE*DE/(DS*DS)                                               LSNCS1 1370
      AS=PI*DS*DS/4.0                                                   LSNCS1 1380
      GO TO 104                                                         LSNCS1 1390
103   GEOFAC=0.0                                                        LSNCS1 1400
      AEASG=DE/DS                                                       LSNCS1 1410
      AS=DS*HNB                                                         LSNCS1 1420
104   LBNOZ=SQRT(LSNOZ*LSNOZ+((DE-DS)/2.0)**2)                          LSNCS1 1430
C                                                                       LSNCS1 1440
C                                                                       LSNCS1 1450
C***********************************************************************LSNCS1 1460
C*                                                                     *LSNCS1 1470
C*              CALCULATE THE SECONDARY FLOW RATES AND P0              *LSNCS1 1480
C*                                                                     *LSNCS1 1490
C***********************************************************************LSNCS1 1500
C                                                                       LSNCS1 1510
C                                                                       LSNCS1 1520
      NSNOZ=NSPNOZ*NPNOZ                                                LSNCS1 1530
      XS=RL*(XFPP2+0.5*XFPP3)/(XFSR1*NSNOZ)                             LSNCS1 1540
      WS=XS*MW                                                          LSNCS1 1550
      PS=WS*SQRT(RBAR*T0/MW)/(AS*WM(GC,1.0))                            LSNCS1 1560
      P0=PS*POPM(GC,1.0)                                                LSNCS1 1570
C                                                                       LSNCS1 1580
C                                                                       LSNCS1 1590
C***********************************************************************LSNCS1 1600
C*                                                                     *LSNCS1 1610
C*          ITERATE ME TO ESTABLISH THE NOZZLE EXIT CONDITIONS         *LSNCS1 1620
C*                                                                     *LSNCS1 1630
C***********************************************************************LSNCS1 1640
C                                                                       LSNCS1 1650
C                                                                       LSNCS1 1660
      NTYPE=1                                                           LSNCS1 1670
      NIT=1                                                             LSNCS1 1680
      CALL MAAS(GC,1.0,AEASG,SUP,5.0E-06,MSUPD,FAIL)                    LSNCS1 1690
      IF(FAIL.EQ.YES) GO TO 107                                         LSNCS1 1700
      DELME=MSUPD-1.0                                                   LSNCS1 1710
      ME=MSUPD                                                          LSNCS1 1720
      DO 105 ITER1=1,100                                                LSNCS1 1730
      AEASE=AASM(GC,ME)                                                 LSNCS1 1740
```

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      PE=PO/POPM(GC,ME)                                                 LSNCS1 1750
      TE=TO/TOTM(GC,ME)                                                 LSNCS1 1760
      VE=ME*SQRT(GC*RBAR*TE/MW)                                         LSNCS1 1770
      CALL LBLAYR(A,B,GEOFAC,LPNOZ,MW,PE,TE,TO,VE,DELTA,RE)             LSNCS1 1780
      DEF=DE-2.0*DELTA                                                  LSNCS1 1790
      XAFASE=DEF/DS                                                     LSNCS1 1800
      IF(GEOMSN.EQ.AX) XAFASE=XAFASE*XAFASE                             LSNCS1 1810
      SIGMA=AFASE-XAFASE+1.0                                            LSNCS1 1820
      ERROR=AFASE*5.0E-06                                               LSNCS1 1830
      CALL ITER(ME,DELME,5.0E-06,-1.0,SIGMA,1.0,ERROR,NIT,NTYPE,XNEG,   LSNCS1 1840
     -YNEG,XPOS,YPOS,NSIGN1,NSIGN2)                                     LSNCS1 1850
      IF(NTYPE.EQ.3) GO TO 106                                          LSNCS1 1860
      IF(ME.LT.1.0.OR.ME.GT.MSUPD) GO TO 108                            LSNCS1 1870
105   CONTINUE                                                          LSNCS1 1880
      GO TO 109                                                         LSNCS1 1890
106   AEE=AFASE*AS                                                      LSNCS1 1900
C                                                                       LSNCS1 1910
C                                                                       LSNCS1 1920
C***********************************************************************LSNCS1 1930
C*                                                                     *LSNCS1 1940
C*                     RECALCULATE THE SECONDARY STREAM PROPERTIES     *LSNCS1 1950
C*                       BASED ON  THE NOZZLE EXIT TEMPERATURE         *LSNCS1 1960
C*                                                                     *LSNCS1 1970
C***********************************************************************LSNCS1 1980
C                                                                       LSNCS1 1990
C                                                                       LSNCS1 2000
      CALL CPCALC(6,9,TE,XE,GE,MW)                                      LSNCS1 2010
C                                                                       LSNCS1 2020
C                                                                       LSNCS1 2030
C***********************************************************************LSNCS1 2040
C*                                                                     *LSNCS1 2050
C*              CALCULATE THE TOTAL SECONDARY MOLAR FLOW RATES AND     *LSNCS1 2060
C*              EFFECTIVE  NOZZLE  EXIT AREAS  FOR SECONDARY  FLOW     *LSNCS1 2070
C*                                                                     *LSNCS1 2080
C***********************************************************************LSNCS1 2090
C                                                                       LSNCS1 2100
C                                                                       LSNCS1 2110
      XKMS=XS*NSNOZ                                                     LSNCS1 2120
      AKMSC=AEE*NSNOZ                                                   LSNCS1 2130
      AKMSE=AKMSC*WM(GC,ME)/WM(GE,ME)                                   LSNCS1 2140
      RETURN                                                            LSNCS1 2150
C                                                                       LSNCS1 2160
C                                                                       LSNCS1 2170
C***********************************************************************LSNCS1 2180
C*                                                                     *LSNCS1 2190
C*                            FAILURE INDICATORS                       *LSNCS1 2200
C*                                                                     *LSNCS1 2210
C***********************************************************************LSNCS1 2220
C                                                                       LSNCS1 2230
C                                                                       LSNCS1 2240
107   WRITE(6,201)                                                      LSNCS1 2250
      RETURN                                                            LSNCS1 2260
108   WRITE(6,202)                                                      LSNCS1 2270
      GO TO 110                                                         LSNCS1 2280
109   WRITE(6,203)                                                      LSNCS1 2290
```

```
110   WRITE(6,204) A,B,GC,MW,ME,MSUPD,RE,WS,TE,TO,PE,PS,PO,XAEASE,AEASE  LSNCS1 2300
      FAIL=YES                                                          LSNCS1 2310
C                                                                       LSNCS1 2320
C                                                                       LSNCS1 2330
C***********************************************************************LSNCS1 2340
C*                                                                     *LSNCS1 2350
C*                           FORMAT STATEMENTS                         *LSNCS1 2360
C*                                                                     *LSNCS1 2370
C***********************************************************************LSNCS1 2380
C                                                                       LSNCS1 2390
C                                                                       LSNCS1 2400
201   FORMAT(*0*,T2,*SUBROUTINE MAAS WAS CALLED FROM SUBROUTINE*,/,T2,  LSNCS1 2410
     -*LSNCS1 FOR THE CALCULATION OF MSUPD FROM AEASE*)                 LSNCS1 2420
202   FORMAT(*1*,T2,*IMPOSSIBLE VALUE FOR ME*,/,T2,*PROGRAM TERMINATED ILSNCS1 2430
     -N SUBROUTINE LSNCS1*)                                             LSNCS1 2440
203   FORMAT(*1*,T2,*CONVERGENCE FAILURE IN SUBROUTINE LSNCS1 FOR ME SUCLSNCS1 2450
     -H THAT XAEASE=AEASE*)                                             LSNCS1 2460
204   FORMAT(*0*,T2,*A        =*,E13.6,T38,*B        =*,E13.6,/,        LSNCS1 2470
     -T2,*GC       =*,E13.6,T38,*MW       =*,E13.6,* KG/KMOLE*,/,       LSNCS1 2480
     -T2,*ME       =*,E13.6,T38,*MSUPD    =*,E13.6,/,                   LSNCS1 2490
     -T2,*RE       =*,E13.6,T38,*WS       =*,E13.6,* KG/S*,/,           LSNCS1 2500
     -T2,*TE       =*,E13.6,* K*,T38,*TO       =*,E13.6,* K*,/,         LSNCS1 2510
     -T2,*PE       =*,E13.6,* PA*,T38,*PS       =*,E13.6,* PA*,/,       LSNCS1 2520
     -T2,*PO       =*,E13.6,* PA*,T38,*XAEASE =*,E13.6,/,               LSNCS1 2530
     -T2,*AEASE   =*,E13.6)                                             LSNCS1 2540
      END                                                               LSNCS1 2550
```

```
      SUBROUTINE LSNCS2(DE,DS,GEOMSN,HNB,LSNOZ,NPNOZ,NSPNOZ,T0,AEASE,   LSNCS2 0100
     -AEASG,AKMSC,AKMSE,FAIL,GC,GE,ME,MW,NSNOZ,PE,P0,RE,TE,XKMS)        LSNCS2 0110
C                                                                       LSNCS2 0120
C                                                                       LSNCS2 0130
C***********************************************************************LSNCS2 0140
C*                                                                     *LSNCS2 0150
C*        LASER SECONDARY NOZZLE CALCULATION SUBROUTINE (LSNCS2)       *LSNCS2 0160
C*                                                                     *LSNCS2 0170
C***********************************************************************LSNCS2 0180
C                                                                       LSNCS2 0190
C***********************************************************************LSNCS2 0200
C*                                                                     *LSNCS2 0210
C* GIVEN A CONSTANT-AREA LASER NOZZLE CONFIGURATION, SUBROUTINE LSNCS2 *LSNCS2 0220
C* CALCULATES THE SECONDARY COMBUSTOR OR STAGNATION PRESSURE  REQUIRED *LSNCS2 0230
C* TO ACHIEVE A GIVEN LASER CAVITY MIXTURE RATIO.                      *LSNCS2 0240
C*                                                                     *LSNCS2 0250
C* INPUT VARIABLES:                                                    *LSNCS2 0260
C*                                                                     *LSNCS2 0270
C* DFORHF = CONTROL VARIABLE SUCH THAT:                                *LSNCS2 0280
C*        = "DF" FOR A DF CHEMICAL LASER                               *LSNCS2 0290
C*        = "HF" FOR A HF CHEMICAL LASER                               *LSNCS2 0300
C* DE     = SECONDARY NOZZLE EXIT DIAMETER (M)                         *LSNCS2 0310
C* DS     = DS (M)                                                     *LSNCS2 0320
C* GEOMSN = SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:      *LSNCS2 0330
C*        = "AX" FOR AXISYMMETRIC NOZZLES                              *LSNCS2 0340
C*        = "2D" FOR SLIT NOZZLES                                      *LSNCS2 0350
C* HNB    = HEIGHT OF NOZZLE BANK (M)                                  *LSNCS2 0360
C* LSNOZ  = LENGTH OF SECONDARY NOZZLE (M)                             *LSNCS2 0370
C* NPNOZ  = NUMBER OF PRIMARY NOZZLES PER KMOLE/S OF PRIMARY FLOW      *LSNCS2 0380
C*          (S/KMOLE)                                                  *LSNCS2 0390
C* NSPNOZ = NUMBER OF SECONDARY-TO-PRIMARY NOZZLES                     *LSNCS2 0400
C* RL     = LASER CAVITY MIXTURE RATIO                                 *LSNCS2 0410
C* T0     = COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE (K)             *LSNCS2 0420
C* XFPP2   = MOLE FRACTION OF F2 IN PRIMARY STREAM                     *LSNCS2 0430
C* XFPP3   = MOLE FRACTION OF F IN PRIMARY STREAM                      *LSNCS2 0440
C* XFSR1  = MOLE FRACTION OF D2 IN SECONDARY STREAM                    *LSNCS2 0450
C* XFSR2  = MOLE FRACTION OF HE IN SECONDARY STREAM                    *LSNCS2 0460
C* XFSR3  = MOLE FRACTION OF N2 IN SECONDARY STREAM                    *LSNCS2 0470
C*                                                                     *LSNCS2 0480
C* OUTPUT VARIABLES:                                                   *LSNCS2 0490
C*                                                                     *LSNCS2 0500
C* AEASE  = A/A*, EFFECTIVE                                            *LSNCS2 0510
C* AEASG  = A/A*, GEOMETRIC                                            *LSNCS2 0520
C* AKMSC  = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR SECONDARY FLOW PER    *LSNCS2 0530
C*          KMOLE/S OF PRIMARY FLOW BASED ON THE COMBUSTOR TEMPERATURE *LSNCS2 0540
C*          (S-M2/KMOLE)                                               *LSNCS2 0550
C* AKMSE  = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR SECONDARY FLOW PER    *LSNCS2 0560
C*          KMOLE/S OF PRIMARY FLOW BASED ON THE EXIT TEMPERATURE      *LSNCS2 0570
C*          (S-M2/KMOLE)                                               *LSNCS2 0580
C* FAIL   = ERROR FLAG                                                 *LSNCS2 0590
C* GC     = GAMMA OF THE SECONDARY STREAM BASED ON THE COMBUSTOR       *LSNCS2 0600
C*          TEMPERATURE                                                *LSNCS2 0610
C* GE     = GAMMA OF THE SECONDARY STREAM BASED ON THE EXIT            *LSNCS2 0620
C*          TEMPERATURE                                                *LSNCS2 0630
C* ME     = MACH NUMBER AT THE NOZZLE EXIT                             *LSNCS2 0640
```

```
C* MW      = MOLECULAR WEIGHT OF THE SECONDARY STREAM (KG/KMOLE)        *LSNCS2 0650
C* NSNOZ   = NUMBER OF SECONDARY NOZZLES PER KMOLE/S OF PRIMARY FLOW    *LSNCS2 0660
C*           (G/KMOLE)                                                  *LSNCS2 0670
C* PE      = STATIC PRESSURE AT THE NOZZLE EXIT (PA)                    *LSNCS2 0680
C* P0      = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)               *LSNCS2 0690
C* RE      = REYNOLDS NUMBER AT THE NOZZLE EXIT                         *LSNCS2 0700
C* TE      = STATIC TEMPERATURE AT THE NOZZLE EXIT (K)                  *LSNCS2 0710
C* XKMS    = TOTAL SECONDARY MOLAR FLOW RATE PER KMOLE/S OF PRIMARY     *LSNCS2 0720
C*           FLOW                                                       *LSNCS2 0730
C*                                                                      *LSNCS2 0740
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS                     *LSNCS2 0750
C*                                                                      *LSNCS2 0760
C***********************************************************************LSNCS2 0770
C                                                                        LSNCS2 0780
C                                                                        LSNCS2 0790
      IMPLICIT REAL(M)                                                   LSNCS2 0800
      REAL LSNOZ,NPNOZ,NSNOZ,NSPNOZ                                      LSNCS2 0810
C                                                                        LSNCS2 0820
      DIMENSION XF(11)                                                   LSNCS2 0830
C                                                                        LSNCS2 0840
      COMMON/CCS3/DFORHF                                                 LSNCS2 0850
      COMMON/CCS8/RL                                                     LSNCS2 0860
      COMMON/CCS14/XFPP2                                                 LSNCS2 0870
      COMMON/CCS15/XFPP3                                                 LSNCS2 0880
      COMMON/CCS16/XFSR1,XFSR2,XFSR3                                     LSNCS2 0890
C                                                                        LSNCS2 0900
      DATA PI/3.14159265358979/,RBAR/8.31434E+03/                        LSNCS2 0910
      DATA AX/2HAX/,HF/2HHF/,SUP/3HSUP/,YES/3HYES/                       LSNCS2 0920
C                                                                        LSNCS2 0930
C                                                                        LSNCS2 0940
C***********************************************************************LSNCS2 0950
C*                                                                      *LSNCS2 0960
C*                          FUNCTION STATEMENTS                         *LSNCS2 0970
C*                                                                      *LSNCS2 0980
C***********************************************************************LSNCS2 0990
C                                                                        LSNCS2 1000
C                                                                        LSNCS2 1010
      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M                                      LSNCS2 1020
      POPM(G,M)=TOTM(G,M)**(G/(G-1.0))                                   LSNCS2 1030
      WM(G,M)=M*SQRT(G*TOTM(G,M))                                        LSNCS2 1040
C                                                                        LSNCS2 1050
C                                                                        LSNCS2 1060
C***********************************************************************LSNCS2 1070
C*                                                                      *LSNCS2 1080
C*                  CALCULATE THE SECONDARY STREAM PROPERTIES           *LSNCS2 1090
C*                     BASED ON  THE CUMBUSTOR TEMPERATURE              *LSNCS2 1100
C*                                                                      *LSNCS2 1110
C***********************************************************************LSNCS2 1120
C                                                                        LSNCS2 1130
C                                                                        LSNCS2 1140
      XF(6)=XFSR2                                                        LSNCS2 1150
      XF(7)=XFSR3                                                        LSNCS2 1160
      IF(DFORHF.EQ.HF) GO TO 101                                         LSNCS2 1170
      XF(8)=XFSR1                                                        LSNCS2 1180
      XF(9)=0.0                                                          LSNCS2 1190
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```
      GO TO 102                                                         LSNCS2 1200
101   XF(8)=0.0                                                         LSNCS2 1210
      XF(9)=XFSR1                                                       LSNCS2 1220
102   CALL VISC(6,9,XF,A,B)                                             LSNCS2 1230
      CALL CPCALC(6,9,TO,XF,GC,MW)                                      LSNCS2 1240
C                                                                       LSNCS2 1250
C                                                                       LSNCS2 1260
C***********************************************************************LSNCS2 1270
C*                                                                     *LSNCS2 1280
C*                           NOZZLE GEOMETRY CALCULATIONS              *LSNCS2 1290
C*                                                                     *LSNCS2 1300
C***********************************************************************LSNCS2 1310
C                                                                       LSNCS2 1320
C                                                                       LSNCS2 1330
      AEASG=1.0                                                         LSNCS2 1340
      AEASE=AEASG                                                       LSNCS2 1350
      IF(GEOMSN.EQ.AX) AS=PI*DS*DS/4.0                                  LSNCS2 1360
      IF(GEOMSN.NE.AX) AS=DS*HNB                                        LSNCS2 1370
C                                                                       LSNCS2 1380
C                                                                       LSNCS2 1390
C***********************************************************************LSNCS2 1400
C*                                                                     *LSNCS2 1410
C*                        CALCULATE THE SECONDARY FLOW RATES           *LSNCS2 1420
C*                                                                     *LSNCS2 1430
C***********************************************************************LSNCS2 1440
C                                                                       LSNCS2 1450
C                                                                       LSNCS2 1460
      NSNOZ=NSPNOZ*NPNOZ                                                LSNCS2 1470
      XS=RL*(XFPP2+0.5*XFPP3)/(XFSR1*NSNOZ)                             LSNCS2 1480
      WS=XS*MW                                                          LSNCS2 1490
C                                                                       LSNCS2 1500
C                                                                       LSNCS2 1510
C***********************************************************************LSNCS2 1520
C*                                                                     *LSNCS2 1530
C*                        CALCULATE THE NOZZLE EXIT CONDITIONS         *LSNCS2 1540
C*                                                                     *LSNCS2 1550
C***********************************************************************LSNCS2 1560
C                                                                       LSNCS2 1570
C                                                                       LSNCS2 1580
      ME=1.0                                                            LSNCS2 1590
      PE=WS*SQRT(RBAR*TO/MW)/(AS*WM(GC,ME))                             LSNCS2 1600
      TF=TO/TTM(GC,ME)                                                  LSNCS2 1610
      VE=ME*SQRT(GC*RBAR*TF/MW)                                         LSNCS2 1620
      POS=PE*POPM(GC,ME)                                                LSNCS2 1630
C                                                                       LSNCS2 1640
C                                                                       LSNCS2 1650
C***********************************************************************LSNCS2 1660
C*                                                                     *LSNCS2 1670
C*                          CALCULATE THE FRICTION FACTOR              *LSNCS2 1680
C*                                                                     *LSNCS2 1690
C***********************************************************************LSNCS2 1700
C                                                                       LSNCS2 1710
C                                                                       LSNCS2 1720
      IF(GEOMSN.EQ.AX) GO TO 103                                        LSNCS2 1730
      CALL LBLAYR(A,B,0.0,LSNOZ,MW,PE,TE,TO,VE,DUMMY,RE)                LSNCS2 1740
```

```
      F=0.148*RE**(-1/5)                                                LSNCS2 1750
      HYDIA=2.0*DE*HNH/(DE+HNH)                                         LSNCS2 1760
      FFLD=4.0*F*LSNOZ/HYDIA                                            LSNCS2 1770
      GO TO 106                                                         LSNCS2 1780
103   MU=EXP(A*ALOG(TE)+B)                                              LSNCS2 1790
      RE=WS*DS/(MU*AS)                                                  LSNCS2 1800
      FX=1.0E+10                                                        LSNCS2 1810
      DO 104 I=1,1000                                                   LSNCS2 1820
      C1=RE*SQRT(4.0*FX)                                                LSNCS2 1830
      C2=-0.8+2.0*ALOG10(C1)                                            LSNCS2 1840
      F=1.0/(4.0*C2*C2)                                                 LSNCS2 1850
      ERROR=(FX-F)*100.0/FX                                             LSNCS2 1860
      IF(ABS(ERROR).LT.5.0E-06) GO TO 105                               LSNCS2 1870
104   FX=F                                                              LSNCS2 1880
      GO TO 109                                                         LSNCS2 1890
105   FFLD=4.0*F*LSNOZ/DE                                               LSNCS2 1900
C                                                                       LSNCS2 1910
C                                                                       LSNCS2 1920
C***********************************************************************LSNCS2 1930
C*                                                                     *LSNCS2 1940
C*                             CALCULATE P0                            *LSNCS2 1950
C*                                                                     *LSNCS2 1960
C***********************************************************************LSNCS2 1970
C                                                                       LSNCS2 1980
106   C1=(GC-1.0)/2.0                                                   LSNCS2 1990
      C2=(GC+1.0)/2.0                                                   LSNCS2 2000
      C3=C2/GC                                                          LSNCS2 2010
      XM2=1.0E-10                                                       LSNCS2 2020
      DO 107 I=1,1000                                                   LSNCS2 2030
      C4=1.0-XM2                                                        LSNCS2 2040
      C5=GC*XM2                                                         LSNCS2 2050
      C6=C2*XM2                                                         LSNCS2 2060
      C7=1.0+C1*XM2                                                     LSNCS2 2070
      H=C4/C5+C3*ALOG(C6/C7)-FFLD                                       LSNCS2 2080
      HP=-(C5+GC*C4)/(C5*C5)+C3*(C2*C7-C1*C6)/(C7*C6)                   LSNCS2 2090
      M2=XM2-H/HP                                                       LSNCS2 2100
      ERROR=(XM2-M2)*100.0/XM2                                          LSNCS2 2110
      IF(ABS(ERROR).LT.5.0E-06) GO TO 108                               LSNCS2 2120
107   XM2=M2                                                            LSNCS2 2130
      GO TO 110                                                         LSNCS2 2140
108   P0POS=SQRT((((1.0+C1*M2)/C2)**(C2/C1))/M2)                        LSNCS2 2150
      P0=P0POS*POS                                                      LSNCS2 2160
C                                                                       LSNCS2 2170
C                                                                       LSNCS2 2180
C***********************************************************************LSNCS2 2190
C*                                                                     *LSNCS2 2200
C*              RECALCULATE THE SECONDARY STREAM PROPERTIES            *LSNCS2 2210
C*                 BASED ON THE  NOZZLE EXIT TEMPERATURE               *LSNCS2 2220
C*                                                                     *LSNCS2 2230
C***********************************************************************LSNCS2 2240
C                                                                       LSNCS2 2250
C                                                                       LSNCS2 2260
      CALL CPCALC(6,9,TE,XE,GE,MW)                                      LSNCS2 2270
C                                                                       LSNCS2 2280
C                                                                       LSNCS2 2290
```

```
C***********************************************************************LSNCS2 2300
C*                                                                     *LSNCS2 2310
C*          CALCULATE THE TOTAL SECONDARY MOLAR FLOW RATES AND         *LSNCS2 2320
C*          EFFECTIVE  NOZZLE  EXIT  AREA  FOR SECONDARY  FLOW         *LSNCS2 2330
C*                                                                     *LSNCS2 2340
C***********************************************************************LSNCS2 2350
C                                                                       LSNCS2 2360
C                                                                       LSNCS2 2370
      XKMS=XS*NSNOZ                                                     LSNCS2 2380
      AKMSC=AS*NSNOZ                                                    LSNCS2 2390
      AKMSE=AKMSC*WM(GC,ME)/WM(RE,ME)                                   LSNCS2 2400
      RETURN                                                            LSNCS2 2410
C                                                                       LSNCS2 2420
C                                                                       LSNCS2 2430
C***********************************************************************LSNCS2 2440
C*                                                                     *LSNCS2 2450
C*                          FAILURE INDICATORS                         *LSNCS2 2460
C*                                                                     *LSNCS2 2470
C***********************************************************************LSNCS2 2480
C                                                                       LSNCS2 2490
C                                                                       LSNCS2 2500
109   WRITE(6,201)                                                      LSNCS2 2510
      GO TO 111                                                         LSNCS2 2520
110   WRITE(6,202)                                                      LSNCS2 2530
111   WRITE(6,203)GC,MW,XM2,M2,FX,F,RE,FFLD                             LSNCS2 2540
      FAIL=YES                                                          LSNCS2 2550
C                                                                       LSNCS2 2560
C                                                                       LSNCS2 2570
C***********************************************************************LSNCS2 2580
C*                                                                     *LSNCS2 2590
C*                          FORMAT STATEMENTS                          *LSNCS2 2600
C*                                                                     *LSNCS2 2610
C***********************************************************************LSNCS2 2620
C                                                                       LSNCS2 2630
C                                                                       LSNCS2 2640
201   FORMAT(*1*,T2,*CONVERGENCE FAILURE IN SUBROUTINE LSNCS2 FOR FX=F*)LSNCS2 2650
202   FORMAT(*1*,T2,*CONVERGENCE FAILURE IN SUBROUTINE LSNCS2 FOR M2=XM2LSNCS2 2660
     -*)                                                                LSNCS2 2670
203   FORMAT(*0*,T2,*GC     =*,E13.6,T38,*MW     =*,E13.6,* KG/KMOLE*,/,LSNCS2 2680
     -T2,*XM2    =*,E13.6,T38,*M2     =*,E13.6,/,                       LSNCS2 2690
     -T2,*FX     =*,E13.6,T38,*F      =*,E13.6,/,                       LSNCS2 2700
     -T2,*RE     =*,E13.6,T38,*FFLD   =*,E13.6)                         LSNCS2 2710
      END                                                               LSNCS2 2720
```

```
      SUBROUTINE MAAS(G,MINI,AAS,FLOW,ERROR,MNEW,FAIL)                  MAAS   0100
C                                                                       MAAS   0110
C                                                                       MAAS   0120
C***********************************************************************MAAS   0130
C*                                                                     *MAAS   0140
C*                                 SUBROUTINE (MAAS)                   *MAAS   0150
C*                                                                     *MAAS   0160
C***********************************************************************MAAS   0170
C                                                                       MAAS   0180
C***********************************************************************MAAS   0190
C*                                                                     *MAAS   0200
C* SUBROUTINE MASS CALCULATES THE MACH NUMBER (M) GIVEN THE AREA RATIO *MAAS   0210
C* (A/A*) BY LINEAR ITERATION.                                         *MAAS   0220
C*                                                                     *MAAS   0230
C* INPUT VARIABLES:                                                    *MAAS   0240
C*                                                                     *MAAS   0250
C* AAS    = THE AREA RATIO A/A*                                        *MAAS   0260
C* ERROR  = MAX PERCENT DEVIATION IN MOLD AND MNEW FOR A SOLUTION      *MAAS   0270
C* FLOW   = CONTROL VARIALBE SUCH THAT:                                *MAAS   0280
C*        = "SUB" FOR THE SUBSONIC BRANCH                              *MAAS   0290
C*        = "SUP" FOR THE SUPERSONIC BRANCH                            *MAAS   0300
C* G      = SPECIFIC HEAT RATIO                                        *MAAS   0310
C* MINI   = INITIAL VALUE OF MACH NUMBER                               *MAAS   0320
C*                                                                     *MAAS   0330
C* OUTPUT VARIABLES:                                                   *MAAS   0340
C*                                                                     *MAAS   0350
C* FAIL   = ERROR FLAG                                                 *MAAS   0360
C* MNEW   = FINAL VALUE OF MACH NUMBER                                 *MAAS   0370
C*                                                                     *MAAS   0380
C***********************************************************************MAAS   0390
C                                                                       MAAS   0400
C                                                                       MAAS   0410
      IMPLICIT REAL(M)                                                  MAAS   0420
      DATA YES/3HYES/,SUP/3HSUP/                                        MAAS   0430
C                                                                       MAAS   0440
C                                                                       MAAS   0450
C***********************************************************************MAAS   0460
C*                                                                     *MAAS   0470
C*                             CALCULATE CONSTANTS                     *MAAS   0480
C*                                                                     *MAAS   0490
C***********************************************************************MAAS   0500
C                                                                       MAAS   0510
C                                                                       MAAS   0520
      G1=(G-1.0)/2.0                                                    MAAS   0530
      G1I=1.0/G1                                                        MAAS   0540
      G2=2.0/(G+1.0)                                                    MAAS   0550
      G2I=1.0/G2                                                        MAAS   0560
      G4=(G+1.0)/(2.0*(G-1.0))                                          MAAS   0570
      G4I=1.0/G4                                                        MAAS   0580
C                                                                       MAAS   0590
C                                                                       MAAS   0600
C***********************************************************************MAAS   0610
C*                                                                     *MAAS   0620
C*                    CALCULATE THE SUPERSONIC BRANCH                  *MAAS   0630
C*                                                                     *MAAS   0640
```

```
C***********************************************************************
C
C
      MOLD=MINI
      IF(FLOW.NE.SUP) GO TO 2
      DO 1 J=1,200
      C1=(MOLD*AAS)**G4I
      MNEW=SQRT(G1I*(G2I*C1-1.0))
      XERROR=(MNEW-MOLD)*100.0/MOLD
      MOLD=MNEW
      IF(ABS(XERROR).LT.ERROR) RETURN
1     CONTINUE
      GO TO 4
C
C
C***********************************************************************
C*                                                                     *
C*                  CALCULATE THE SUBSONIC BRANCH                      *
C*                                                                     *
C***********************************************************************
C
C
2     DO 3 J=1,200
      C1=1.0+G1*MOLD*MOLD
      MNEW=((G2*C1)**G4)/AAS
      XERROR=(MNEW-MOLD)*100.0/MOLD
      MOLD=MNEW
      IF(ABS(XERROR).LT.ERROR) RETURN
3     CONTINUE
C
C
C***********************************************************************
C*                                                                     *
C*                      CONVERGENCE FAILURE                            *
C*                                                                     *
C***********************************************************************
C
C
4     WRITE(6,5)FLOW,G,MINI,MNEW,AAS,XERROR,ERROR
      FAIL=YES
5     FORMAT(*1*,T2,*CONVERGENCE FAILURE FOR *,A3,*SONIC *,
     -*BRANCH IN SUBROUTINE MAAS*,/,
     -T2,*G      =*,E13.6,2X,*MINI    =*,E13.6,/,
     -T2,*MNEW   =*,E13.6,2X,*AAS     =*,E13.6,/,
     -T2,*XERROR =*,E13.6,2X,*ERROR   =*,E13.6)
      END
```

```
      SUBROUTINE OUTLDS                                                 OUTLDS 0100
C                                                                       OUTLDS 0110
C                                                                       OUTLDS 0120
C***********************************************************************OUTLDS 0130
C*                                                                     *OUTLDS 0140
C*                   OUTPUT SUBROUTINE (OUTLDS)                        *OUTLDS 0150
C*                                                                     *OUTLDS 0160
C***********************************************************************OUTLDS 0170
C                                                                       OUTLDS 0180
C***********************************************************************OUTLDS 0190
C*                                                                     *OUTLDS 0200
C*     SUBROUTINE OUTLDS PRINTS THE LASER DEVICE SECTION RESULTS OF    *OUTLDS 0210
C*     PROGRAM  CLAP IN SI UNITS ON TERMINALS WITH A MINIMUM OF 132    *OUTLDS 0220
C*     CHARACTERS PER LINE.                                            *OUTLDS 0230
C*                                                                     *OUTLDS 0240
C***********************************************************************OUTLDS 0250
C                                                                       OUTLDS 0260
C                                                                       OUTLDS 0270
      IMPLICIT REAL(L,M,N)                                              OUTLDS 0280
C                                                                       OUTLDS 0290
      COMMON/CCS11/W7W2                                                 OUTLDS 0300
C                                                                       OUTLDS 0310
      COMMON/LDS2/D1,D1S,D3,D3S,GEOMPN,GEOMSN,LDSS2,LPNOZ,LSNOZ,NSPNOZ, OUTLDS 0320
     -PKFRAC,P10,T10,T30,T70                                            OUTLDS 0330
C                                                                       OUTLDS 0340
      COMMON/LDS3/A1,A1A1SF,A1A1SG,A2,A3,A3A3SF,A3A3SG,A4,A5,A6,G1,G2,  OUTLDS 0350
     -G3,G4,G5,G6,G7,LSEP,MW1,MW2,MW3,MW4,MW5,MW6,MW7,M1,M2,M3,M4,M5,M6,OUTLDS 0360
     -NPNOZ,NSNOZ,P1,P2,P3,P30,P4,P5,P50,P6,P60,RE1,RE3,RE6,R1,R10,R2,  OUTLDS 0370
     -R20,R3,R30,R4,R40,R5,R50,R6,R60,T1,T2,T20,T3,T4,T40,T5,T50,T6,T60,OUTLDS 0380
     -W3W1,W5W2,W6W2,W8W2,X3X1,X4X2,X5X2,X6X2,X7X2,X8X2                 OUTLDS 0390
C                                                                       OUTLDS 0400
      COMMON/LDS4/A8,G8,MW8,M8,P8,P80,R8,R80,T8,T80                     OUTLDS 0410
C                                                                       OUTLDS 0420
      COMMON/LDS5/BRFRAC,CANGLE,HBASE,HNB,LCAV                          OUTLDS 0430
C                                                                       OUTLDS 0440
      COMMON/LDS6/P20,P40,W4W2                                          OUTLDS 0450
C                                                                       OUTLDS 0460
      COMMON/MAIN2/FLOW                                                 OUTLDS 0470
C                                                                       OUTLDS 0480
      DATA CHOKE/5HCHOKE/,SEP/3HSEP/                                    OUTLDS 0490
C                                                                       OUTLDS 0500
C                                                                       OUTLDS 0510
C***********************************************************************OUTLDS 0520
C*                                                                     *OUTLDS 0530
C*                      OUTPUT INITIAL DATA                            *OUTLDS 0540
C*                                                                     *OUTLDS 0550
C***********************************************************************OUTLDS 0560
C                                                                       OUTLDS 0570
C                                                                       OUTLDS 0580
      WRITE(20,201)                                                     OUTLDS 0590
      IF(LDSS2.EQ.3HP10) WRITE(20,202)BRFRAC,CANGLE,D1,D1S,D3,D3S,      OUTLDS 0600
     -GEOMPN,GEOMSN,HBASE,HNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T30,T70OUTLDS 0610
      IF(LDSS2.EQ.3HT10) WRITE(20,203)BRFRAC,CANGLE,D1,D1S,D3,D3S,      OUTLDS 0620
     -GEOMPN,GEOMSN,HBASE,HNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,T10,T30,T70OUTLDS 0630
C                                                                       OUTLDS 0640
```

```
C
C***********************************************************************
C*                                                                     *
C*                        OUTPUT RESULTANT DATA                        *
C*                                                                     *
C***********************************************************************
C
C
      WRITE(20,204)A1,A1A1SE,A1A1SG,G1,MW1,M1,NPNOZ,P1,P10,RE1,R1,R10,
     -T1,T10
      WRITE(20,205)A2,G2,MW2,M2,P2,P20,R2,R20,T2,T20
      WRITE(20,206)A3,A3A3SE,A3A3SG,G3,MW3,M3,NSNOZ,P3,P30,RE3,R3,R30,
     -T3,T30,W3W1,X3X1
      WRITE(20,207)A4,G4,MW4,M4,P4,P40,R4,R40,T4,T40,W4W2,X4X2
      WRITE(20,208)A5,G5,MW5,M5,P5,P50,R5,R50,T5,T50,W5W2,X5X2
      WRITE(20,209)A6,G6,MW6,M6,P6,P60,R6,R60,T6,T60,W6W2,X6X2
      WRITE(20,210)G7,MW7,T70,W7W2,X7X2
      IF(FLOW.EQ.SEP) GO TO 101
      IF(FLOW.EQ.CHOKE) GO TO 102
      WRITE(20,211)A8,G8,MW8,M8,P8,P80,RE8,R8,R80,T8,T80,W8W2,X8X2
      RETURN
101   WRITE(20,212)
      WRITE(20,213)A8,G8,LSEP,MW8,M8,P8,P80,RE8,R8,R80,T8,T80,W8W2,X8X2
      RETURN
102   WRITE(20,214)
C
C
C***********************************************************************
C*                                                                     *
C*                          FORMAT STATEMENTS                          *
C*                                                                     *
C***********************************************************************
C
C
201   FORMAT(*1*,T55,*LASER DEVICE SECTION*,//,T60,*INITIAL DATA:*)
202   FORMAT(*0*,T32,*BRFRAC   =*,E13.6,T66,*CANGLE   =*,E13.6,* RAD*,/,
     -T32,*D1       =*,E13.6,* M*,T66,*D1S      =*,E13.6,* M*,/,
     -T32,*D3       =*,E13.6,* M*,T66,*D3S      =*,E13.6,* M*,/,
     -T32,*GEOMPN   =*,A13,T66,*GEOMSN   =*,A13,/,
     -T32,*HBASE    =*,E13.6,* M*,T66,*HNB      =*,E13.6,* M*,/,
     -T32,*LCAV     =*,E13.6,* M*,T66,*LPNOZ    =*,E13.6,* M*,/,
     -T32,*LSNOZ    =*,E13.6,* M*,T66,*NSPNOZ   =*,E13.6,/,
     -T32,*PKFRAC   =*,E13.6,T66,*P10      =*,E13.6,* PA*,/,
     -T32,*T30      =*,E13.6,* K*,T66,*T70      =*,E13.6,* K*)
203   FORMAT(*0*,T32,*BRFRAC   =*,E13.6,T66,*CANGLE   =*,E13.6,* RAD*,/,
     -T32,*D1       =*,E13.6,* M*,T66,*D1S      =*,E13.6,* M*,/,
     -T32,*D3       =*,E13.6,* M*,T66,*D3S      =*,E13.6,* M*,/,
     -T32,*GEOMPN   =*,A13,T66,*GEOMSN   =*,A13,/,
     -T32,*HBASE    =*,E13.6,* M*,T66,*HNB      =*,E13.6,* M*,/,
     -T32,*LCAV     =*,E13.6,* M*,T66,*LPNOZ    =*,E13.6,* M*,/,
     -T32,*LSNOZ    =*,E13.6,* M*,T66,*NSPNOZ   =*,E13.6,/,
     -T32,*PKFRAC   =*,E13.6,T66,*T10      =*,E13.6,* K*,/,
     -T32,*T30      =*,E13.6,* K*,T66,*T70      =*,E13.6,* K*)
204   FORMAT(*0*,T59,*RESULTANT DATA:*,//,T23,*POINT 1  PRIMARY NOZZLE E
     -XIT - CONDITIONS BASED ON THE NOZZLE STAGNATION*,/,T32,*(COMBUSTOR
```

```
     -) TEMPERATURE*,//,                                                OUTLDS 1200
     -T32,*A1         =*,E13.6,* S-M2/KMOLE*,T66,*A1A1SE  =*,E13.6,/,  OUTLDS 1210
     -T32,*A1A1SG   =*,F13.6,T66,*01        =*,E13.6,/,                  OUTLDS 1220
     -T32,*MW1       =*,F13.6,* KG/KMOLE*,T66,*M1        =*,F13.6,/,    OUTLDS 1230
     -T32,*NPNOZ     =*,F13.6,* S/KMOLE*,T66,*P1        =*,E13.6,* PA*,/,  OUTLDS 1240
     -T32,*P10       =*,E13.6,* PA*,T66,*RF1       =*,E13.6,/,          OUTLDS 1250
     -T32,*R1        =*,F13.6,* KG/M3*,T66,*R10       =*,E13.6,* KG/M3*,/,  OUTLDS 1260
     -T32,*T1        =*,E13.6,* K*,T66,*T10       =*,F13.6,* K*)        OUTLDS 1270
205   FORMAT(*0*,T23,*POINT 2  PRIMARY NOZZLE EXIT - CONDITIONS BASED ONOUTLDS 1280
     - THE NOZZLE EXIT*,/,T32,*TEMPERATURE*,//,                         OUTLDS 1290
     -T32,*A2        =*,E13.6,* S-M2/KMOLE*,T66,*02        =*,E13.6,/,  OUTLDS 1300
     -T32,*MW2       =*,F13.6,* KG/KMOLE*,T66,*M2        =*,F13.6,/,    OUTLDS 1310
     -T32,*P2        =*,E13.6,* PA*,T66,*P20       =*,F13.6,* PA*,/,    OUTLDS 1320
     -T32,*R2        =*,E13.6,* KG/M3*,T66,*R20       =*,E13.6,* KG/M3*,/,  OUTLDS 1330
     -T32,*T2        =*,F13.6,* K*,T66,*T20       =*,F13.6,* K*)        OUTLDS 1340
206   FORMAT(*0*,T23,*POINT 3  SECONDARY NOZZLE EXIT - CONDITIONS BASED OUTLDS 1350
     -ON THE NOZZLE STAGNATION*,/,T32,*(COMBUSTOR) TEMPERATURE*,//,     OUTLDS 1360
     -T32,*A3        =*,F13.6,* S-M2/KMOLE*,T66,*A3A3SE  =*,E13.6,/,    OUTLDS 1370
     -T32,*A3A3SG   =*,F13.6,T66,*03        =*,E13.6,/,                  OUTLDS 1380
     -T32,*MW3       =*,E13.6,* KG/KMOLE*,T66,*M3        =*,F13.6,/,    OUTLDS 1390
     -T32,*NSNOZ     =*,E13.6,* S/KMOLE*,T66,*P3        =*,E13.6,* PA*,/,  OUTLDS 1400
     -T32,*P30       =*,E13.6,* PA*,T66,*RF3       =*,E13.6,/,          OUTLDS 1410
     -T32,*R3        =*,F13.6,* KG/M3*,T66,*R30       =*,E13.6,* KG/M3*,/,  OUTLDS 1420
     -T32,*T3        =*,F13.6,* K*,T66,*T30       =*,F13.6,* K*,/,      OUTLDS 1430
     -T32,*W3W1     =*,F13.6,T66,*X3X1     =*,E13.6)                     OUTLDS 1440
207   FORMAT(*0*,T23,*POINT 4  SECONDARY NOZZLE EXIT - CONDITIONS BASED OUTLDS 1450
     -ON THE NOZZLE EXIT*,/,T32,*TEMPERATURE*,//,                       OUTLDS 1460
     -T32,*A4        =*,F13.6,* S-M2/KMOLE*,T66,*04        =*,E13.6,/,  OUTLDS 1470
     -T32,*MW4       =*,F13.6,* KG/KMOLE*,T66,*M4        =*,F13.6,/,    OUTLDS 1480
     -T32,*P4        =*,E13.6,* PA*,T66,*P40       =*,E13.6,* PA*,/,    OUTLDS 1490
     -T32,*R4        =*,F13.6,* KG/M3*,T66,*R40       =*,E13.6,* KG/M3*,/,  OUTLDS 1500
     -T32,*T4        =*,E13.6,* K*,T66,*T40       =*,F13.6,* K*,/,      OUTLDS 1510
     -T32,*W4W2     =*,F13.6,T66,*X4X2     =*,E13.6)                     OUTLDS 1520
208   FORMAT(*1*,T23,*POINT 5  CONSTANT-AREA MIXING REGION EXIT*,//,    OUTLDS 1530
     -T32,*A5        =*,E13.6,* S-M2/KMOLE*,T66,*05        =*,E13.6,/,  OUTLDS 1540
     -T32,*MW5       =*,E13.6,* KG/KMOLE*,T66,*M5        =*,F13.5,/,    OUTLDS 1550
     -T32,*P5        =*,E13.6,* PA*,T66,*P50       =*,E13.6,* PA*,/,    OUTLDS 1560
     -T32,*R5        =*,E13.6,* KG/M3*,T66,*R50       =*,E13.6,* KG/M3*,/,  OUTLDS 1570
     -T32,*T5        =*,E13.6,* K*,T66,*T50       =*,F13.6,* K*,/,      OUTLDS 1580
     -T32,*W5W2     =*,E13.6,T66,*X5X2     =*,E13.6)                     OUTLDS 1590
209   FORMAT(*0*,T23,*POINT 6  ISENTROPIC EXPANSION REGION EXIT*,//,    OUTLDS 1600
     -T32,*A6        =*,E13.6,* S-M2/KMOLE*,T66,*06        =*,E13.6,/,  OUTLDS 1610
     -T32,*MW6       =*,E13.6,* KG/KMOLE*,T66,*M6        =*,F13.6,/,    OUTLDS 1620
     -T32,*P6        =*,E13.6,* PA*,T66,*P60       =*,E13.6,* PA*,/,    OUTLDS 1630
     -T32,*R6        =*,E13.6,* KG/M3*,T66,*R60       =*,E13.6,* KG/M3*,/,  OUTLDS 1640
     -T32,*T6        =*,F13.6,* K*,T66,*T60       =*,F13.6,* K*,/,      OUTLDS 1650
     -T32,*W6W2     =*,E13.6,T66,*X6X2     =*,E13.6)                     OUTLDS 1660
210   FORMAT(*0*,T23,*POINT 7  MIRROR PURGE CONDITIONS*,//,             OUTLDS 1670
     -T32,*G7        =*,E13.6,T66,*MW7       =*,E13.6,* KG/KMOLE*,/,    OUTLDS 1680
     -T32,*T70       =*,E13.6,* K*,T66,*W7W2     =*,E13.6,/,            OUTLDS 1690
     -T32,*X7X2     =*,E13.6)                                            OUTLDS 1700
211   FORMAT(*0*,T23,*POINT 8  LASER CAVITY EXIT*,//,                   OUTLDS 1710
     -T32,*A8        =*,E13.6,* S-M2/KMOLE*,T66,*08        =*,E13.6,/,  OUTLDS 1720
     -T32,*MW8       =*,E13.6,* KG/KMOLE*,T66,*M8        =*,E13.6,/,    OUTLDS 1730
     -T32,*P8        =*,E13.6,* PA*,T66,*P80       =*,E13.6,* PA*,/,    OUTLDS 1740
```

```
     -T32,*REB      =*,E13.6,T66,*RB       =*,E13.6,* KG/M3*,/,           OUTLDS 1750
     -T32,*RBO      =*,F13.6,* KG/M3*,T66,*TB       =*,E13.6,* K*,/,      OUTLDS 1760
     -T32,*TBO      =*,F13.6,* K*,T66,*WBW2     =*,F13.6,/,               OUTLDS 1770
     -T32,*XBX2     =*,E13.6)                                             OUTLDS 1780
212   FORMAT(*0*,T23,*WARNING: THE CAVITY FLOW HAS SEPARATED.  ALL FURTHOUTLDS 1790
     -ER RESULTS SHOULD BE USED*,/,T32,*WITH CAUTION.*)                   OUTLDS 1800
213   FORMAT(*0*,T23,*POINT A  LASER CAVITY EXIT*,//,                     OUTLDS 1810
     -T32,*AA       =*,E13.6,* S-M2/KMOLE*,T66,*GA       =*,E13.6,/,      OUTLDS 1820
     -T32,*LSEP     =*,F13.6,* M*,T66,*MWA      =*,F13.6,* KG/KMOLE*,/,   OUTLDS 1830
     -T32,*MA       =*,E13.6,T66,*PA       =*,E13.6,* PA*,/,              OUTLDS 1840
     -T32,*PAO      =*,E13.6,* PA*,T66,*REA      =*,E13.6,/,              OUTLDS 1850
     -T32,*RA       =*,F13.6,* KG/M3*,T66,*RAO      =*,E13.6,* KG/M3*,/,  OUTLDS 1860
     -T32,*TA       =*,F13.6,* K*,T66,*TAO      =*,F13.6,* K*,/,          OUTLDS 1870
     -T32,*WAW2     =*,E13.6,T66,*XAX2     =*,E13.6)                      OUTLDS 1880
214   FORMAT(*0*,T23,*WARNING: THE CAVITY FLOW HAS CHOKED.  ALL FURTHER OUTLDS 1890
     -CALCULATIONS HAVE*,/,T32,*BEEN DISCONTINUED*)                       OUTLDS 1900
      END                                                                 OUTLDS 1910
```

```
      SUBROUTINE VISC(NS1,NS2,XF,A,B)                                   VISC
C                                                                       VISC
C                                                                       VISC
C***********************************************************************VISC
C*                                                                     *VISC
C*                 VISCOSITY CALCULATION SUBROUTINE (VISC)             *VISC
C*                                                                     *VISC
C***********************************************************************VISC
C                                                                       VISC
C***********************************************************************VISC
C*                                                                     *VISC
C*    SUBROUTINE VISC CALCULATES A RELATIONSHIP FOR THE ABSOLUTE       *VISC
C*    VISCOSITY OF GAS MIXTURES AS A FUNCTION OF TEMPERATURE.  THIS    *VISC
C*    RELATIONSHIP IS OF THE FORM:                                     *VISC
C*                                                                     *VISC
C*                              ALOG(MU)=A*ALOG(T)+B                   *VISC
C*                                                                     *VISC
C* INPUT VARIABLES:                                                    *VISC
C*                                                                     *VISC
C* NS1     = DO LOOP LIMIT                                             *VISC
C* NS2     = DO LOOP LIMIT                                             *VISC
C* XF(I)   = MOLE FRACTION OF THE I-TH SPECIES                         *VISC
C*                                                                     *VISC
C* OUTPUT VARIABLES:                                                   *VISC
C*                                                                     *VISC
C* A       = SLOPE [ALOG(N-S/M2)/ALOG(K)]                              *VISC
C* B       = INTERSECT [ALOG(N-S/M2)]                                  *VISC
C*                                                                     *VISC
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS.                   *VISC
C*                                                                     *VISC
C***********************************************************************VISC
C                                                                       VISC
C                                                                       VISC
      IMPLICIT REAL(M)                                                  VISC
      REAL NUM                                                          VISC
      DIMENSION MU(11,15),MW(11),XF(11)                                 VISC
C                                                                       VISC
      DATA MW/                                                          VISC
C           CF4          F2           F            HF           DF      VISC
     -      88.0047,     37.9968,     18.9984,     20.0064,     21.0125,VISC
C           HE           N2           D2           H2           D       VISC
     -      4.00260,     28.0134,     4.02820,     2.01594,     2.01410,VISC
C           H                                                           VISC
     -      1.00797/                                                    VISC
C                                                                       VISC
C                                                                       VISC
C***********************************************************************VISC
C*                                                                     *VISC
C* MU VALUES ARE STORED IN UNITS OF [1.0E+07 N-S/M2] AND TABULATED BY  *VISC
C* TEMPERATURE (ROW) FROM 300 K TO 3100 K IN INCREMENTS OF 200 K  AND  *VISC
C* SPECIES (COLUMN).                                                   *VISC
C*                                                                     *VISC
C* VISCOSITY DATA WAS TAKEN FROM:  NASA TECH REPORT R-132,  TABLE III  *VISC
C* EXCEPT THAT VALUES FOR D2, DF, AND D WERE CALCULATED FROM DATA FOR  *VISC
C* H2, HF, AND H  ASSUMING THE  VISCOSITY TO  BE PROPORTIONAL TO  THE  *VISC
```

```
C* SQUARE ROOT OF THE MOLECULAR WEIGHT RATIO.                          *VISC   0650
C*                                                                     *VISC   0660
C***********************************************************************VISC   0670
C                                                                       VISC    680
C                                                                       VISC   0690
      DATA ((MU(I,J),I=1,9),J=1,15)/                                    VISC   0700
C         CF4     F2      F       HF      OF      HE      N2      O2      H2    VISC   0710
     - 176.7, 236.2, 213.7, 125.3, 131.9, 203.9, 177.7, 126.1,  89.2,   VISC   0720
     - 262.7, 346.0, 313.0, 206.2, 213.2, 283.5, 252.7, 178.3, 126.1,   VISC   0730
     - 333.6, 436.5, 394.9, 277.3, 284.3, 352.2, 315.6, 221.6, 156.8,   VISC   0740
     - 395.9, 516.8, 467.5, 339.9, 346.9, 414.2, 371.0, 260.8, 184.5,   VISC   0750
     - 452.8, 589.5, 533.3, 396.6, 403.6, 471.4, 422.7, 297.6, 210.5,   VISC   0760
     - 505.2, 656.5, 593.8, 448.5, 455.6, 525.1, 471.8, 331.8, 234.7,   VISC   0770
     - 554.0, 719.6, 651.0, 496.9, 504.3, 575.8, 517.9, 364.0, 257.5,   VISC   0780
     - 600.3, 780.7, 706.3, 542.2, 549.9, 624.3, 561.7, 394.7, 279.2,   VISC   0790
     - 645.0, 840.4, 760.2, 585.2, 593.3, 670.7, 603.7, 424.1, 300.0,   VISC   0800
     - 689.0, 897.1, 811.6, 626.5, 634.9, 715.4, 644.0, 452.5, 320.1,   VISC   0810
     - 731.5, 951.9, 861.1, 666.2, 681.8, 758.6, 683.0, 479.8, 339.4,   VISC   0820
     - 772.5,1004.9, 909.0, 704.5, 721.0, 800.5, 720.8, 506.3, 358.2,   VISC   0830
     - 812.2,1056.3, 955.6, 741.4, 758.7, 841.3, 757.5, 532.1, 376.4,   VISC   0840
     - 850.8,1106.4,1000.8, 777.2, 795.4, 880.9, 793.3, 557.1, 394.1,   VISC   0850
     - 888.4,1155.2,1045.0, 811.8, 830.8, 919.7, 828.1, 581.7, 411.5/   VISC   0860
      DATA ((MU(I,J),I=10,11),J=1,15)/                                  VISC   0870
C         D       H                                                     VISC   0880
     - 105.9,  74.9,                                                    VISC   0890
     - 147.3, 104.2,                                                    VISC   0900
     - 183.6, 129.9,                                                    VISC   0910
     - 216.3, 153.0,                                                    VISC   0920
     - 246.2, 174.2,                                                    VISC   0930
     - 274.2, 194.0,                                                    VISC   0940
     - 300.8, 212.8,                                                    VISC   0950
     - 326.1, 230.7,                                                    VISC   0960
     - 350.3, 247.8,                                                    VISC   0970
     - 373.7, 264.4,                                                    VISC   0980
     - 396.2, 280.3,                                                    VISC   0990
     - 418.1, 295.8,                                                    VISC   1000
     - 439.5, 310.9,                                                    VISC   1010
     - 460.1, 325.5,                                                    VISC   1020
     - 480.3, 339.8/                                                    VISC   1030
C                                                                       VISC   1040
C                                                                       VISC   1050
C***********************************************************************VISC   1060
C*                                                                     *VISC   1070
C*    CALCULATE THE ABSOLUTE VISCOSITY OF THE MIXTURE.  REF: BIRD,     *VISC   1080
C*    STEWART, & LIGHTFOOT, P.24.                                      *VISC   1090
C*                                                                     *VISC   1100
C***********************************************************************VISC   1110
C                                                                       VISC   1120
C                                                                       VISC   1130
      SX=0.0                                                            VISC   1140
      SX2=0.0                                                           VISC   1150
      SY=0.0                                                            VISC   1160
      SXY=0.0                                                           VISC   1170
      DO 103 K=1,15                                                     VISC   1180
      SUMI=0.0                                                          VISC   1190
```

```
      DO 102 I=NS1,NS2
      SUMJ=0.0
      DO 101 J=NS1,NS2
      R1=MW(I)/MW(J)
      R2=MU(I,K)/MU(J,K)
      C=1.0+SQRT(R2/SQRT(R1))
      PHI=C*C/SQRT(8.0*(1.0+R1))
      DEN=XF(J)*PHI
101   SUMJ=SUMJ+DEN
      NUM=XF(I)*MU(I,K)
      DIV=NUM/SUMJ
102   SUMI=SUMI+DIV
      MUMIX=SUMI*1.0E-07
C
C
C***********************************************************************
C*                                                                     *
C* PERFORM A LINEAR LEAST SQUARES FIT FOR ALOG(MUMIX) AS A FUNCTION OF *
C* ALOG(T).                                                            *
C*                                                                     *
C***********************************************************************
C
C
      T=100.0*(FLOAT(K)*2.0+1.0)
      X=ALOG(T)
      Y=ALOG(MUMIX)
      SX=SX+X
      SX2=SX2+X*X
      SY=SY+Y
103   SXY=SXY+X*Y
      A=(15.0*SXY-SX*SY)/(15.0*SX2-SX*SX)
      B=(SY/15.0)-A*(SX/15.0)
      END
```

Appendix D. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)-OVERLAY PRS

```
      OVERLAY(PRS,3,0)
      PROGRAM PRS
C
C
C***********************************************************************
C*                                                                     *
C*                  PRESSURE RECOVERY OVERLAY (PRS)                    *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C* OVERLAY PRS CONTROLS THE PRESSURE RECOVERY CALCULATIONS FOR PROGRAM *
C* CLAP.                                                               *
C*                                                                     *
C*                      GENERAL NOTATION SCHEME                        *
C*                                                                     *
C* A : AREA PER KMOLE/S OF LASER PRIMARY FLOW (S-M2/KMOLE)             *
C* G : (GAMMA) SPECIFIC HEAT RATIO                                     *
C* M : MACH NUMBER                                                     *
C* MW: MOLECULAR WEIGHT (KG/KMOLE)                                     *
C* P : PRESSURE (PA)                                                   *
C* R : DENSITY (KG/M3)                                                 *
C* T : TEMPERATURE (K)                                                 *
C* W : MASS FLOW RATE (KG/S)                                           *
C* X : MOLAR FLOW RATE (KMOLE/S)                                       *
C*                                                                     *
C* REPEATED LETTERS INDICATE RATIOS.                                   *
C* EXAMPLE: A2A1 = A2/A1                                               *
C*                                                                     *
C* VARIABLES ARE DESIGNATED AS TO LOCATION BY THE FOLLOWING:           *
C*                                                                     *
C* POINT 1: LASER CAVITY EXIT                                          *
C* POINT 2: NORMAL SHOCK DIFFUSER EXIT                                 *
C* POINT 3: SUBSONIC DIFFUSER EXIT                                     *
C* POINT 4: EJECTOR SECONDARY NOZZLE EXIT                              *
C* POINT 5: EJECTOR PRIMARY NOZZLE EXIT                                *
C* POINT 6: EJECTOR MIXING TUBE EXIT                                   *
C* POINT 7: SUBSONIC DIFFUSER EXIT                                     *
C* EXAMPLE: M5 = EJECTOR PRIMARY NOZZLE EXIT MACH NUMBER               *
C*                                                                     *
C* 0: INDICATES STAGNATION CONDITIONS                                  *
C* EXAMPLE: T20 = NORMAL SHOCK DIFFUSER EXIT STAGNATION TEMPERATURE    *
C*                                                                     *
C* VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED AS REQUIRED.        *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(L,M,N)
C
      COMMON/LDS1/LDSS1
C
      COMMON/LDS4/A1,G1,MW1,M1,P1,P10,R1,R10,T1,T10
C
```

```
      COMMON/MAIN1/FAIL                                                 PRS     0650
C                                                                       PRS     0660
      COMMON/PRS1/PRSS1                                                 PRS     0670
C                                                                       PRS     0680
      COMMON/PRS2/A2,A3,A4,A7,ETA23,ETA67,G2,G3,G4,G6,G7,MW2,MW3,MW4,   PRS     0690
     -MW6,MW7,M2,M3,M4,M6,M7,P2,P20,P3,P30,P4,P40,P5,P6,P60,P70,R2,R20, PRS     0700
     -R3,R30,R4,R40,R5,R50,R6,R60,R7,R70,T2,T20,T3,T30,T4,T40,T5,T6,T60,PRS     0710
     -T7,T70,W2W1,W3W1,W4W1,W6W1,W7W1,X2X1,X3X1,X4X1,X5X1,X6X1,X7X1     PRS     0720
C                                                                       PRS     0730
      COMMON/PRS3/A3A2,A7A6,ETA12,LIMIT,MW5,P7,T50                      PRS     0740
C                                                                       PRS     0750
      COMMON/PRS4/A5,A6,M5,W5W1                                         PRS     0760
C                                                                       PRS     0770
      COMMON/PRS5/EJECT                                                 PRS     0780
C                                                                       PRS     0790
      COMMON/PRS6/G5,P50                                                PRS     0800
C                                                                       PRS     0810
      DATA RBAR/8.31434E+03/                                            PRS     0820
      DATA CAE/3HCAE/,NO/2HNO/,SSE/3HSSE/,YES/3HYES/                    PRS     0830
C                                                                       PRS     0840
C                                                                       PRS     0850
C***********************************************************************PRS     0860
C*                                                                     *PRS     0870
C*                          GAS DYNAMIC FUNCTIONS                      *PRS     0880
C*                                                                     *PRS     0890
C***********************************************************************PRS     0900
C                                                                       PRS     0910
C                                                                       PRS     0920
      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M                                     PRS     0930
      POPM(G,M)=TOTM(G,M)**(G/(G-1.0))                                  PRS     0940
      WM(G,M)=M*SQRT(G*TOTM(G,M))                                       PRS     0950
      RHO(P,T,MW)=P*MW/(RBAR*T)                                         PRS     0960
C                                                                       PRS     0970
C                                                                       PRS     0980
C***********************************************************************PRS     0990
C*                                                                     *PRS     1000
C*                            READ INPUT DATA                          *PRS     1010
C*                                                                     *PRS     1020
C***********************************************************************PRS     1030
C                                                                       PRS     1040
C                                                                       PRS     1050
      CALL INPRS                                                        PRS     1060
      IF(EJECT.EQ.NO) GO TO 206                                         PRS     1070
      IF(LDSS1.EQ.YES) PRSS1=YES                                        PRS     1080
      IF(PRSS1.EQ.NO) GO TO 104                                         PRS     1090
      IF(EJECT.EQ.SSE) GO TO 102                                        PRS     1100
C                                                                       PRS     1110
C                                                                       PRS     1120
C***********************************************************************PRS     1130
C*                                                                     *PRS     1140
C*                   NORMAL SHOCK DIFFUSER CALCULATIONS                *PRS     1150
C*                                                                     *PRS     1160
C***********************************************************************PRS     1170
C                                                                       PRS     1180
C                                                                       PRS     1190
```

```
      CALL NSDS(G1,M1,ETA12,M2,P2P1,P20P10,T2T1,T20T10)
      A2=A1
      G2=G1
      MW2=MW1
      P2=P2P1*P1
      P20=P20P10*P10
      T2=T2T1*T1
      T20=T20T10*T10
      R2=RHO(P2,T2,MW2)
      R20=RHO(P20,T20,MW2)
      W2W1=1.0
      X2X1=1.0
C
C
C*****************************************************************
C*                                                               *
C*                  SUBSONIC DIFFUSER CALCULATIONS               *
C*                                                               *
C*****************************************************************
C
C
      CALL SDS(G2,M2,A3A2,M3,P3P2,P30P20,T3T2,T30T20,ETA23,FAIL)
      IF(FAIL.EQ.YES) GO TO 105
      A3=A3A2*A2
      G3=G2
      MW3=MW2
      P3=P3P2*P2
      P30=P30P20*P20
      T3=T3T2*T2
      T30=T30T20*T20
      R3=RHO(P3,T3,MW3)
      R30=RHO(P30,T30,MW3)
      W3W1=W2W1
      X3X1=X2X1
      IF(EJECT.EQ.CAE) GO TO 101
      WRITE(6,204)(P3,M3,K=1,10)
      GO TO 104
C
C
C*****************************************************************
C*                                                               *
C*                SUDDEN ENLARGEMENT CALCULATIONS                *
C*                                                               *
C*****************************************************************
C
C
101   G4=G3
      MW4=MW3
      P40=P30
      T40=T30
      W4W1=W3W1
      X4X1=X3X1
C
C
C*****************************************************************
```

```
C*                                                                     *PRS    1750
C*   OPTIMUM CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR CALCULATIONS   *PRS    1760
C*                                                                     *PRS    1770
C***********************************************************************PRS    1780
C                                                                       PRS    1790
C                                                                       PRS    1800
      MW5MW4=MW5/MW4                                                    PRS    1810
      P50P40=P50/P40                                                    PRS    1820
      P7P40=P7/P40                                                      PRS    1830
      T50T40=T50/T40                                                    PRS    1840
      CALL CAEOS(A7A6,G4,G5,MW5MW4,P50P40,P7P40,T50T40,A6A5,ETA67,FAIL, PRS    1850
     -G6,MW6MW5,M4,M5,M6,M7,P5P4,P6P5,P60P50,P7P6,P70P60,T5T4,T6T5,     PRS    1860
     -T60T50,T7T6,T70T60,W5W4)                                          PRS    1870
      IF(FAIL.EQ.YES) GO TO 106                                         PRS    1880
      MW6=MW6MW5*MW5                                                    PRS    1890
      P5=P50/P0PM(G5,M5)                                                PRS    1900
      P4=P5/P5P4                                                        PRS    1910
      P6=P6P5*P5                                                        PRS    1920
      P60=P60P50*P50                                                    PRS    1930
      T5=T50/T0TM(G5,M5)                                                PRS    1940
      T4=T5/T5T4                                                        PRS    1950
      T6=T6T5*T5                                                        PRS    1960
      T60=T60T50*T50                                                    PRS    1970
      R4=RHO(P4,T4,MW4)                                                 PRS    1980
      R40=RHO(P40,T40,MW4)                                              PRS    1990
      R5=RHO(P5,T5,MW5)                                                 PRS    2000
      R50=RHO(P50,T50,MW5)                                              PRS    2010
      R6=RHO(P6,T6,MW6)                                                 PRS    2020
      R60=RHO(P60,T60,MW6)                                              PRS    2030
      W5W1=W5W4*W4W1                                                    PRS    2040
      W6W1=W5W1+W4W1                                                    PRS    2050
      X5X1=W5W1*MW1/MW5                                                 PRS    2060
      X6X1=X5X1+X4X1                                                    PRS    2070
      A6=A1*W6W1*(P1/P6)*SQRT((MW1/MW6)*(T60/T10))*(WK(G1,M1)/WM(G6,M6))PRS    2080
      A5=A6/A6A5                                                        PRS    2090
      A4=A6-A5                                                          PRS    2100
      GO TO 103                                                         PRS    2110
C                                                                       PRS    2120
C                                                                       PRS    2130
C***********************************************************************PRS    2140
C*                                                                     *PRS    2150
C*  OPTIMUM CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR CALCULATIONS  *PRS    2160
C*                                                                     *PRS    2170
C***********************************************************************PRS    2180
C                                                                       PRS    2190
C                                                                       PRS    2200
102   MW5MW1=MW5/MW1                                                    PRS    2210
      P50P1=P50/P1                                                      PRS    2220
      P7P1=P7/P1                                                        PRS    2230
      T50T10=T50/T10                                                    PRS    2240
      CALL SSEOS(A7A6,G1,G5,LIMIT,MW5MW1,M1,P50P1,P7P1,T50T10,A6A5,     PRS    2250
     -ETA67,FAIL,G6,MW6MW5,M5,M6,M7,P5P1,P50P10,P6P5,P60P50,P7P6,P70P60,PRS    2260
     -T5T1,T6T5,T60T50,T7T6,T70T60,W5W1)                                PRS    2270
      IF(FAIL.EQ.YES) GO TO 107                                         PRS    2280
      A5=A1/(A6A5-1.0)                                                  PRS    2290
```

```
      P5=P5P1*P1                                                        PRS    2300
      T5=T5T1*T1                                                        PRS    2310
      R5=RHO(P5,T5,MW5)                                                 PRS    2320
      R50=RHO(P50,T50,MW5)                                              PRS    2330
      X5X1=W5W1/MW5MW1                                                  PRS    2340
      A6=A6A5*A5                                                        PRS    2350
      MW6=MW6MW5*MW5                                                    PRS    2360
      P6=P6P5*P5                                                        PRS    2370
      P60=P60P50*P50                                                    PRS    2380
      T6=T6T5*T5                                                        PRS    2390
      T60=T60T50*T50                                                    PRS    2400
      W6W1=W5W1*1.0                                                     PRS    2410
      X6X1=X5X1*1.0                                                     PRS    2420
C                                                                       PRS    2430
C                                                                       PRS    2440
C***********************************************************************PRS    2450
C*                                                                     *PRS    2460
C*                      SUBSONIC DIFFUSER CALCULATIONS                 *PRS    2470
C*                                                                     *PRS    2480
C***********************************************************************PRS    2490
C                                                                       PRS    2500
C                                                                       PRS    2510
103   A7=A7A6*A6                                                        PRS    2520
      G7=G6                                                             PRS    2530
      MW7=MW6                                                           PRS    2540
      P70=P70P60*P60                                                    PRS    2550
      T7=T7T6*T6                                                        PRS    2560
      T70=T70T60*T60                                                    PRS    2570
      R7=RHO(P7,T7,MW7)                                                 PRS    2580
      R70=RHO(P70,T70,MW7)                                              PRS    2590
      W7W1=W6W1                                                         PRS    2600
      X7X1=X6X1                                                         PRS    2610
C                                                                       PRS    2620
C                                                                       PRS    2630
C***********************************************************************PRS    2640
C*                                                                     *PRS    2650
C*                              OUTPUT RESULTS                         *PRS    2660
C*                                                                     *PRS    2670
C***********************************************************************PRS    2680
C                                                                       PRS    2690
C                                                                       PRS    2700
      WRITE(6,205)(P3,M5,K=1,10)                                        PRS    2710
104   CALL OUTPRS                                                       PRS    2720
      GO TO 206                                                         PRS    2730
C                                                                       PRS    2740
C                                                                       PRS    2750
C***********************************************************************PRS    2760
C*                                                                     *PRS    2770
C*                           FAILURE INDICATORS                        *PRS    2780
C*                                                                     *PRS    2790
C***********************************************************************PRS    2800
C                                                                       PRS    2810
C                                                                       PRS    2820
105   WRITE(6,201)                                                      PRS    2830
      GO TO 206                                                         PRS    2840
```

```
106   WRITE(6,202)                                                      PRS    2850
      GO TO 206                                                         PRS    2860
107   WRITE(6,203)                                                      PRS    2870
C                                                                       PRS    2880
C                                                                       PRS    2890
C***********************************************************************PRS    2900
C*                                                                     *PRS    2910
C*                          FORMAT STATEMENTS                          *PRS    2920
C*                                                                     *PRS    2930
C***********************************************************************PRS    2940
201   FORMAT(*0*,T2,*PROGRAM TERMINATED IN SUBROUTINE SDS AS CALLED FROMPRS    2950
     - SUBROUTINE PRS*)                                                 PRS    2960
202   FORMAT(*0*,T2,*SUBROUTINE CAEOS WAS CALLED FROM SUBROUTINE PRS*)  PRS    2970
203   FORMAT(*0*,T2,*SUBROUTINE SSEOS WAS CALLED FROM SUBROUTINE PRS*)  PRS    2980
204   FORMAT(*1*,10(T2,*NOTE: P3 =*,E13.6,* PA   M3 =*,E13.6,/))        PRS    2990
205   FORMAT(*1*,10(T2,*NOTE: P3 =*,E13.6,* PA   M5 =*,E13.6,/))        PRS    3000
206   END                                                               PRS    3010
```

```
      SUBROUTINE CAEFC(GS,GP,MS1,MP1,AP1AM3,PS1PP1,FAIL)
C
C
C***********************************************************************
C*                                                                     *
C*       CONSTANT-AREA EJECTOR FABRI CRITERION SUBROUTINE (CAEFC)      *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C* SUBROUTINE  CAEFC PERFORMS THE  CONSTANT-AREA, SUBSONIC-SUPERSONIC  *
C* EJECTOR FABRI CRITERION  CALCULATIONS BY  ONE-DIMENSIONAL ANALYSIS  *
C* FOR A SUPERSONIC PRIMARY (MP1>1) AND  A SUBSONIC SECONDARY (MS1<1)  *
C* WHICH CHOKES IN THE EJECTOR SHROUD (MS2=1).  THIS EJECTOR ANALYSIS  *
C* IS BASED ON THE CONSTANT-AREA  SHROUD, EJECTOR  ANALYSIS OF FABRI.  *
C* REFERENCE: NACA TM 1410.                                            *
C*                                                                     *
C* INPUT VARIABLES:                                                    *
C*                                                                     *
C* GS     = SECONDARY GAMMA                                            *
C* GP     = PRIMARY GAMMA                                              *
C* MS1    = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE             *
C* MP1    = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE               *
C* AP1AM3 = PRIMARY-TO-MIXING TUBE AREA RATIO                          *
C*                                                                     *
C* OUTPUT VARIABLES:                                                   *
C*                                                                     *
C* PS1PP1 = SECONDARY-TO-PRIMARY STATIC PRESSURE RATIO                 *
C* FAIL   = ERROR FLAG                                                 *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
      DATA YES/3HYES/,PART/4HPART/,SUP/3HSUP/
C
C
C***********************************************************************
C*                                                                     *
C*                        GAS DYNAMIC FUNCTIONS                        *
C*                                                                     *
C***********************************************************************
C
C
      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M
      PPOM(G,M)=TOTM(G,M)**(-G/(G-1.0))
      AASM(G,M)=((2.0*TOTM(G,M)/(G+1.0))**(0.5*(G+1.0)/(G-1.0)))/M
C
C
C***********************************************************************
C*                                                                     *
C*                  FABRI*S CRITERION APPLIES ONLY WHEN                *
C*                   (MS1.LE.1.0) AND (PS1PP1.LE.1.0).                 *
C*                                                                     *
```

```
C***********************************************************************CAEFC
C                                                                       CAEFC
C                                                                       CAEFC
      IF(MS1.GT.(1.0)) GO TO 103                                        CAEFC
      IF((1.-MS1).LT.(1.E-4)) GO TO 102                                 CAEFC
C                                                                       CAEFC
C                                                                       CAEFC
C***********************************************************************CAEFC
C*                                                                     *CAEFC
C*        CALCULATE MP2 AT STATION (2) WHERE MS2=1.0 FROM              *CAEFC
C*        THE AREA RATIO FOR STREAM (P) AT STATION (2).                *CAEFC
C*                                                                     *CAEFC
C***********************************************************************CAEFC
C                                                                       CAEFC
C                                                                       CAEFC
      AP2APS=(AASM(GP,MP1)/AP1AM3)*(1.-(1.-AP1AM3)/AASM(GS,MS1)))       CAEFC
      CALL MAAS(GP,MP1,AP2APS,SUP,5.0E-06,MP2,FAIL)                     CAEFC
      IF(FAIL.EQ.YES) GO TO 107                                         CAEFC
      IF(MP2.LT.MP1) GO TO 110                                          CAEFC
      IF((MP2/MP1-1.).LT.(1.E-4)) GO TO 101                             CAEFC
C                                                                       CAEFC
C                                                                       CAEFC
C***********************************************************************CAEFC
C*                                                                     *CAEFC
C* CALCULATE STATIC PRESSURE RATIO PS1PP1 BASED ON FABRI'S CRITERION.  *CAEFC
C*                                                                     *CAEFC
C***********************************************************************CAEFC
C                                                                       CAEFC
C                                                                       CAEFC
      VD=(1.0-AP1AM3)*((1.0+GS*(MS1**2))-                               CAEFC
     -(PPOM(GS,1.0)/PPOM(GS,MS1))*((1.0+GS)/AASM(GS,MS1)))              CAEFC
      VN=(PPOM(GP,MP2)/PPOM(GP,MP1))*AP1AM3*(AASM(GP,MP2)/              CAEFC
     -AASM(GP,MP1)))*(1.+GP*(MP2**2))-AP1AM3*(1.+GP*(MP1**2))           CAEFC
      PS1PP1=VN/VD                                                      CAEFC
      IF(PS1PP1.LE.(0.0)) GO TO 105                                     CAEFC
      IF(PS1PP1.GT.(1.0)) GO TO 101                                     CAEFC
      RETURN                                                            CAEFC
C                                                                       CAEFC
C                                                                       CAEFC
C***********************************************************************CAEFC
C*                                                                     *CAEFC
C*        MS1 IS APPROXIMATELY 1.0 AND MP2 IS APPROXIMATELY MP1.       *CAEFC
C*                                                                     *CAEFC
C***********************************************************************CAEFC
C                                                                       CAEFC
C                                                                       CAEFC
101   IF(MS1.LT.1.0) GO TO 110                                          CAEFC
102   PS1PP1=1.0                                                        CAEFC
      RETURN                                                            CAEFC
C                                                                       CAEFC
C                                                                       CAEFC
C***********************************************************************CAEFC
C*                                                                     *CAEFC
C*                          ERROR MESSAGES                             *CAEFC
C*                                                                     *CAEFC
```

```
C***********************************************************************CAEFC  1200
C                                                                       CAEFC  1210
C                                                                       CAEFC  1220
103   WRITE(6,104)                                                      CAEFC  1230
104   FORMAT(*1*,T2,*ERROR IN SUBROUTINE CAEFC: MS1>1*)                 CAEFC  1240
      GO TO 109                                                         CAEFC  1250
105   WRITE(6,106)                                                      CAEFC  1260
106   FORMAT(*1*,T2,*ERROR IN SUBROUTINE CAEFC: PS1PP1<0*)              CAEFC  1270
      GO TO 109                                                         CAEFC  1280
107   WRITE(6,108)                                                      CAEFC  1290
108   FORMAT(*0*,T2,*SUBROUTINE MAAS WAS CALLED FROM SUBROUTINE CAEFC*) CAEFC  1300
109   FAIL=YES                                                          CAEFC  1310
      RETURN                                                            CAEFC  1320
110   FAIL=PART                                                         CAEFC  1330
      END                                                               CAEFC  1340
```

```
      SUBROUTINE CAEOCV(GS,GP,MWSMWP,TSOTP0,MS1,MP1,AP1AM3,PS1PP1,
     -FLOW,WSWP,GM,MWMMWP,TMOTP0,MM3,PPOPS0,PM3PS0,PM3PP1,FAIL)
C
C
C***********************************************************************
C*                                                                     *
C*   CONSTANT-AREA EJECTOR OVERALL CONTROL VOLUME SUBROUTINE (CAEOCV)  *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C* SUBROUTINE  CAEOCV  PERFORMS  THE  CONSTANT-AREA  EJECTOR, OVERALL  *
C* CONTROL VOLUME CALCULATIONS BY ONE-DIMENSIONAL ANALYSIS FROM INLET  *
C* SECTION (1) TO MIXED SECTION (3).                                   *
C*                                                                     *
C* INPUT VARIABLES:                                                    *
C*                                                                     *
C* GS     = SECONDARY GAMMA                                            *
C* GP     = PRIMARY GAMMA                                              *
C* MWSMWP = SECONDARY-TO-PRIMARY MOLECULAR WEIGHT RATIO                *
C* TSOTP0 = SECONDARY-TO-PRIMARY STAGNATION TEMPERATURE RATIO          *
C* MS1    = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE             *
C* MP1    = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE               *
C* AP1AM3 = PRIMARY-TO-MIXING TUBE AREA RATIO                          *
C* PS1PP1 = SECONDARY-TO-PRIMARY STATIC PRESSURE RATIO                 *
C* FLOW   = CONTROL VARIABLE SUCH THAT:                                *
C*        = "SUB" FOR THE SUBSONIC SOLUTION                            *
C*        = "SUP" FOR THE SUPERSONIC SOLUTION                          *
C*                                                                     *
C* OUTPUT VARIABLES:                                                   *
C*                                                                     *
C* WSWP   = SECONDARY-TO-PRIMARY MASS FLOW RATIO                       *
C* GM     = MIXED STREAM GAMMA                                         *
C* MWMMWP = MIXED STREAM-TO-PRIMARY MOLECULAR WEIGHT RATIO             *
C* TMOTP0 = MIXED STREAM-TO-PRIMARY STAGNATION TEMPERATURE RATIO       *
C* MM3    = MIXED STREAM MACH NO. AT THE MIXING TUBE EXIT              *
C* PPOPS0 = PRIMARY-TO-SECONDARY STAGNATION PRESSURE RATIO             *
C* PM3PS0 = MIXED STREAM STATIC-TO-SECONDARY STAGNATION PRESSURE RATIO *
C* PM3PP1 = MIXED STREAM-TO-PRIMARY STATIC PRESSURE RATIO              *
C* FAIL   = ERROR FLAG                                                 *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
      DATA PART/4HPART/,SUP/3HSUP/
C
C
C***********************************************************************
C*                                                                     *
C*                        GAS DYNAMIC FUNCTIONS                        *
C*                                                                     *
C***********************************************************************
C
```

```
C                                                                       CAEOCV 0650
      WM(G,M)=M*SQRT(G*(1.+.5*(G-1.)*(M**2)))                           CAEOCV 0660
      T(G,M)=(1.+G*(M**2))/(M*SQRT(1.+.5*(G-1.)*(M**2)))                CAEOCV 0670
      PP0M(G,M)=(1.+.5*(G-1.)*(M**2))**(-G/(G-1.))                      CAEOCV 0680
C                                                                       CAEOCV 0690
C                                                                       CAEOCV 0700
C***********************************************************************CAEOCV 0710
C*                                                                     *CAEOCV 0720
C*                        EJECTOR MASS FLOW RATIO                      *CAEOCV 0730
C*                                                                     *CAEOCV 0740
C***********************************************************************CAEOCV 0750
C                                                                       CAEOCV 0760
C                                                                       CAEOCV 0770
      C0=SQRT(MWSMWP/TS0TP0)                                            CAEOCV 0780
      WSWP=PS1PP1*((1.-AP1AM3)/AP1AM3)*C0*(WM(GS,MS1)/WM(GP,MP1))       CAEOCV 0790
      CPSCPP=(GS/GP)*((GP-1.)/(GS-1.))/MWSMWP                           CAEOCV 0800
C                                                                       CAEOCV 0810
C                                                                       CAEOCV 0820
C***********************************************************************CAEOCV 0830
C*                                                                     *CAEOCV 0840
C*                          MIXED FLOW PROPERTIES                      *CAEOCV 0850
C*                                                                     *CAEOCV 0860
C***********************************************************************CAEOCV 0870
C                                                                       CAEOCV 0880
C                                                                       CAEOCV 0890
      MWMMWP=(1.+WSWP)/(1.+(WSWP/MWSMWP))                               CAEOCV 0900
      GM=1./(1.-((GP-1.)/GP)*((1.+(WSWP/MWSMWP))/(1.+CPSCPP*WSWP)))     CAEOCV 0910
      TM0TP0=(1.+WSWP*CPSCPP*TS0TP0)/(1.+WSWP*CPSCPP)                   CAEOCV 0920
C                                                                       CAEOCV 0930
C                                                                       CAEOCV 0940
C***********************************************************************CAEOCV 0950
C*                                                                     *CAEOCV 0960
C*                               SOLVE FOR MM3                         *CAEOCV 0970
C*                                                                     *CAEOCV 0980
C***********************************************************************CAEOCV 0990
C                                                                       CAEOCV 1000
C                                                                       CAEOCV 1010
      C1=SQRT((TS0TP0/MWSMWP)*(GP/GS))                                  CAEOCV 1020
      C2=SQRT(TM0TP0/MWMMWP*(GP/GM))                                    CAEOCV 1030
      TM3=(T(GP,MP1)+C1*WSWP*T(GS,MS1))/((1.+WSWP)*C2)                  CAEOCV 1040
      TM3MIN=SQRT(2.*(GM+1.))                                           CAEOCV 1050
      IF(TM3.LT.TM3MIN) GO TO 10                                        CAEOCV 1060
      C3=(TM3**2-2.*GM)                                                 CAEOCV 1070
      C4=(((GM-1.)/2.)*(TM3**2)-GM**2)                                  CAEOCV 1080
      C5=SQRT(C3**2+4.*C4)                                              CAEOCV 1090
      MSQD3M=(-C3-C5)/(2.*C4)                                           CAEOCV 1100
      MSQD3P=(-C3+C5)/(2.*C4)                                           CAEOCV 1110
C                                                                       CAEOCV 1120
C                                                                       CAEOCV 1130
C***********************************************************************CAEOCV 1140
C*                                                                     *CAEOCV 1150
C*          DETERMINE TWO POSSIBLE MIXED-FLOW MACH NO. SOLUTIONS       *CAEOCV 1160
C*                                                                     *CAEOCV 1170
C***********************************************************************CAEOCV 1180
C                                                                       CAEOCV 1190
```

```
C
      IF(MSQD3M.GE.(0.0)) MM3M=SQRT(MSQD3M)
      IF(MSQD3P.GE.(0.0)) MM3P=SQRT(MSQD3P)
      MM3=MM3P
      IF(FLOW.EQ.SUP) MM3=MM3M
C
C
C***********************************************************************
C*                                                                     *
C*                      CALCULATE PRESSURE RATIOS                      *
C*                                                                     *
C***********************************************************************
C
C
      C6=SQRT(TMOTP0/MWMMWP)
      PM3PP1=C6*AP1AM3*(1.+WSWP)*(WM(GP,MP1)/WM(GM,MM3))
      PP0PS0=(PP0M(GS,MS1)/PP0M(GP,MP1))/PS1PP1
      PM3PS0=PM3PP1*(PP0M(GS,MS1)/PS1PP1)
      RETURN
C
C
C***********************************************************************
C*                                                                     *
C*                            ERROR MESSAGES                           *
C*                                                                     *
C***********************************************************************
C
C
10    FAIL=PART
      END
```

```
      SUBROUTINE CAEOS(A7A6,GS,GP,MWPMWS,P50P40,P7P40,T50T40,A6A5,ETA67,CAEOS  0100
     -FAIL,GM,MWMMWP,M4,M5,M6,M7,P5P4,P6P5,P60P50,P7P6,P70P60,T5T4,T6T5,CAEOS  0110
     -T60T50,T7T6,T70T60,WPWS)                                           CAEOS  0120
C                                                                        CAEOS  0130
C                                                                        CAEOS  0140
C***********************************************************************CAEOS  0150
C*                                                                      *CAEOS  0160
C*     SUBSONIC-SUPERSONIC EJECTOR OPTIMIZATION SUBROUTINE (CAEOS)      *CAEOS  0170
C*                                                                      *CAEOS  0180
C***********************************************************************CAEOS  0190
C                                                                        CAEOS  0200
C***********************************************************************CAEOS  0210
C*                                                                      *CAEOS  0220
C* CAEOS IS A  SUBROUTINE FOR  OPTIMIZING A  CONSTANT-AREA,  SUBSONIC- *CAEOS  0230
C* SUPERSONIC  EJECTOR-SUBSONIC DIFFUSER SUBSYSTEM BY  ONE-DIMENSIONAL *CAEOS  0240
C* ANALYSIS.  THE  OPTIMUM  IS TAKEN TO  BE THAT  CONFIGURATION  WHICH *CAEOS  0250
C* REQUIRES THE MINIMUM DRIVER MASS FLOW FOR A GIVEN DRIVER STAGNATION *CAEOS  0260
C* PRESSURE AND GIVEN COMPRESSION RATIO.                               *CAEOS  0270
C*                                                                      *CAEOS  0280
C* INPUT VARIABLES:                                                     *CAEOS  0290
C*                                                                      *CAEOS  0300
C* A7A6    = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE AREA RATIO              *CAEOS  0310
C* GS      = SECONDARY GAMMA                                            *CAEOS  0320
C* GP      = PRIMARY GAMMA                                              *CAEOS  0330
C* MWPMWS  = PRIMARY-TO-SECONDARY MOLECULAR WEIGHT RATIO                *CAEOS  0340
C* P50P40  = PRIMARY-TO-SECONDARY STAGNATION PRESSURE RATIO             *CAEOS  0350
C* P7P40   = SUBSONIC DIFFUSER EXIT STATIC-TO-SECONDARY STAGNATION      *CAEOS  0360
C*           PRESSURE RATIO                                             *CAEOS  0370
C* T50T40  = PRIMARY-TO-SECONDARY STAGNATION TEMPERATURE RATIO          *CAEOS  0380
C*                                                                      *CAEOS  0390
C* OUTPUT VARIABLES:                                                    *CAEOS  0400
C*                                                                      *CAEOS  0410
C* A6A5    = MIXING TUBE-TO-PRIMARY NOZZLE EXIT AREA RATIO              *CAEOS  0420
C* ETA67   = SUBSONIC DIFFUSER COEFFICIENT                              *CAEOS  0430
C* FAIL    = ERROR FLAG                                                 *CAEOS  0440
C* GM      = MIXED STREAM GAMMA                                         *CAEOS  0450
C* MWMMWP  = MIXED STREAM-TO-PRIMARY MOLECULAR WEIGHT RATIO             *CAEOS  0460
C* M4      = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE             *CAEOS  0470
C* M5      = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE               *CAEOS  0480
C* M6      = MIXED STREAM MACH NO. AT THE MIXING TUBE EXIT              *CAEOS  0490
C* M7      = MACH NO. AT THE SUBSONIC DIFFUSER EXIT                     *CAEOS  0500
C* P5P4    = PRIMARY-TO-SECONDARY STATIC PRESSURE RATIO                 *CAEOS  0510
C* P6P5    = MIXED STREAM-TO-PRIMARY STATIC PRESSURE RATIO              *CAEOS  0520
C* P60P50  = MIXED STREAM-TO-PRIMARY STAGNATION PRESSURE RATIO          *CAEOS  0530
C* P7P6    = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STATIC PRESSURE RATIO   *CAEOS  0540
C* P70P60  = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STAGNATION PRESSURE     *CAEOS  0550
C*           RATIO                                                      *CAEOS  0560
C* T5T4    = PRIMARY-TO-SECONDARY STATIC TEMPERATURE RATIO              *CAEOS  0570
C* T6T5    = MIXED STREAM-TO-PRIMARY STATIC TEMPERATURE RATIO           *CAEOS  0580
C* T60T50  = MIXED STREAM-TO-PRIMARY STAGNATION TEMPERATURE RATIO       *CAEOS  0590
C* T7T6    = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STATIC TEMPERATURE      *CAEOS  0600
C*         = RATIO                                                      *CAEOS  0610
C* T70T60  = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STAGNATION TEMPERATURE  *CAEOS  0620
C*           RATIO                                                      *CAEOS  0630
C* WPWS    = PRIMARY-TO-SECONDARY MASS FLOW RATIO                       *CAEOS  0640
```

```
C*                                                                     *CAEOS 0650
C***********************************************************************CAEOS 0660
C                                                                       CAEOS 0670
C                                                                       CAEOS 0680
      IMPLICIT REAL(M)                                                  CAEOS 0690
      REAL NO                                                           CAEOS 0700
      DATA NO/2HNO/,SUR/3HSUR/,YES/3HYES/                               CAEOS 0710
C                                                                       CAEOS 0720
C                                                                       CAEOS 0730
C***********************************************************************CAEOS 0740
C*                                                                     *CAEOS 0750
C*                           GAS DYNAMIC FUNCTIONS                     *CAEOS 0760
C*                                                                     *CAEOS 0770
C***********************************************************************CAEOS 0780
C                                                                       CAEOS 0790
C                                                                       CAEOS 0800
      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M                                     CAEOS 0810
      POPM(G,M)=TOTM(G,M)**(G/(G-1.0))                                  CAEOS 0820
C                                                                       CAEOS 0830
C                                                                       CAEOS 0840
C***********************************************************************CAEOS 0850
C*                                                                     *CAEOS 0860
C*                    ITERATE M4 TO FIND MINIMUM XWPWS                 *CAEOS 0870
C*                                                                     *CAEOS 0880
C***********************************************************************CAEOS 0890
C                                                                       CAEOS 0900
C                                                                       CAEOS 0910
      MWSMWP=1.0/MWPMWS                                                 CAEOS 0920
      T40T50=1.0/T50T40                                                 CAEOS 0930
      NTYPE1=1                                                          CAEOS 0940
      NIT1=1                                                            CAEOS 0950
      M4=1.0                                                            CAEOS 0960
      DO 110 ITER1=1,1000                                               CAEOS 0970
C                                                                       CAEOS 0980
C                                                                       CAEOS 0990
C***********************************************************************CAEOS 1000
C*                                                                     *CAEOS 1010
C*                  ITERATE A6A5 TO FIND XP50P40=P50P40                *CAEOS 1020
C*                                                                     *CAEOS 1030
C***********************************************************************CAEOS 1040
C                                                                       CAEOS 1050
C                                                                       CAEOS 1060
      NTYPE2=1                                                          CAEOS 1070
      NIT2=1                                                            CAEOS 1080
      A6A5=20.0                                                         CAEOS 1090
      DO 108 ITER2=1,1000                                               CAEOS 1100
C                                                                       CAEOS 1110
C                                                                       CAEOS 1120
C***********************************************************************CAEOS 1130
C*                                                                     *CAEOS 1140
C*                    ITERATE M5 TO FIND XP7P40=P7P40                  *CAEOS 1150
C*                                                                     *CAEOS 1160
C***********************************************************************CAEOS 1170
C                                                                       CAEOS 1180
C                                                                       CAEOS 1190
```

```
      NTYPE3=1                                                          CAEOS 1200
      NIT3=1                                                            CAEOS 1210
      M5=1.01                                                           CAEOS 1220
      DO 106 ITER3=1,1000                                               CAEOS 1230
C                                                                       CAEOS 1240
C                                                                       CAEOS 1250
C***********************************************************************CAEOS 1260
C*                                                                     *CAEOS 1270
C*               CALCULATIONS FOR CONSTANT-AREA EJECTOR                *CAEOS 1280
C*                                                                     *CAEOS 1290
C***********************************************************************CAEOS 1300
C                                                                       CAEOS 1310
C                                                                       CAEOS 1320
      A5A6=1.0/A6A5                                                     CAEOS 1330
      IF(M4.NE.1.0) GO TO 101                                           CAEOS 1340
      P4P5=1.0                                                          CAEOS 1350
      GO TO 102                                                         CAEOS 1360
101   CALL CAFFC(GS,GP,M4,M5,A5A6,P4P5,FAIL)                            CAEOS 1370
      IF(FAIL.EQ.YES) GO TO 112                                         CAEOS 1380
      IF(FAIL.NE.NO) GO TO 103                                          CAEOS 1390
102   CALL CAEOCV(GS,GP,MWSMWP,T40T50,M4,M5,A5A6,P4P5,SUR,WSWP,GM,      CAEOS 1400
     -MWMMWP,T60T50,M6,XP50P40,P6P40,P6P5,FAIL)                         CAEOS 1410
      IF(FAIL.EQ.YES) GO TO 113                                         CAEOS 1420
      IF(FAIL.EQ.NO) GO TO 105                                          CAEOS 1430
C                                                                       CAEOS 1440
C                                                                       CAEOS 1450
C***********************************************************************CAEOS 1460
C*                                                                     *CAEOS 1470
C*            NO CAE SOLUTION EXISTS FOR CURRENT VALUE OF              *CAEOS 1480
C*            M5.  INCREMENT M5 AND SEARCH FOR SOLUTION.               *CAEOS 1490
C*                                                                     *CAEOS 1500
C***********************************************************************CAEOS 1510
C                                                                       CAEOS 1520
C                                                                       CAEOS 1530
103   M5=M5+0.5                                                         CAEOS 1540
      IF(M5.GT.10.0) GO TO 104                                          CAEOS 1550
      FAIL=NO                                                           CAEOS 1560
      GO TO 106                                                         CAEOS 1570
C                                                                       CAEOS 1580
C                                                                       CAEOS 1590
C***********************************************************************CAEOS 1600
C*                                                                     *CAEOS 1610
C*         NO CAE SOLUTION EXISTS FOR CURRENT VALUE OF A6A5.           *CAEOS 1620
C*         INCREMENT A6A5 AND SEARCH FOR SOLUTION.                     *CAEOS 1630
C*                                                                     *CAEOS 1640
C***********************************************************************CAEOS 1650
C                                                                       CAEOS 1660
C                                                                       CAEOS 1670
104   A6A5=A6A5-0.5                                                     CAEOS 1680
      IF(A6A5.LE.1.0) GO TO 109                                         CAEOS 1690
      FAIL=NO                                                           CAEOS 1700
      GO TO 108                                                         CAEOS 1710
C                                                                       CAEOS 1720
C                                                                       CAEOS 1730
C***********************************************************************CAEOS 1740
```

```
C*                                                                     *CAEOS  1750
C*                    CALCULATIONS FOR SUBSONIC DIFFUSER               *CAEOS  1760
C*                                                                     *CAEOS  1770
C***********************************************************************CAEOS  1780
C                                                                       CAEOS  1790
C                                                                       CAEOS  1800
105   CALL SDS(GM,M6,A7A6,M7,P7P6,P70P60,T7T6,T70T60,ETA67,FAIL)        CAEOS  1810
      IF(FAIL.EQ.YES) GO TO 114                                         CAEOS  1820
      XP7P40=P7P6*P6P40                                                 CAEOS  1830
C                                                                       CAEOS  1840
C                                                                       CAEOS  1850
C***********************************************************************CAEOS  1860
C*                                                                     *CAEOS  1870
C*                  TEST FOR XP7P40=P7P40 AND INCREMENT M5             *CAEOS  1880
C*                                                                     *CAEOS  1890
C***********************************************************************CAEOS  1900
C                                                                       CAEOS  1910
C                                                                       CAEOS  1920
      CALL ITER(M5,0.5,5.0E-06,+1.0,XP7P40,P7P40,1.0E-01,NIT3,NTYPE3,   CAEOS  1930
     -XNEG3,YNEG3,XPOS3,YPOS3,NSIGN3,NSIGN4)                            CAEOS  1940
      IF(NTYPE3.EQ.3) GO TO 107                                         CAEOS  1950
106   CONTINUE                                                          CAEOS  1960
      GO TO 116                                                         CAEOS  1970
C                                                                       CAEOS  1980
C                                                                       CAEOS  1990
C***********************************************************************CAEOS  2000
C*                                                                     *CAEOS  2010
C*                TEST FOR XP50P40=P50P40 AND INCREMENT A6A5           *CAEOS  2020
C*                                                                     *CAEOS  2030
C***********************************************************************CAEOS  2040
C                                                                       CAEOS  2050
C                                                                       CAEOS  2060
107   CALL ITER(A6A5,0.5,5.0E-06,-1.0,XP50P40,P50P40,1.0E-01,NIT2,      CAEOS  2070
     -NTYPE2,XNEG2,YNEG2,XPOS2,YPOS2,NSIGN1,NSIGN2)                     CAEOS  2080
      IF(NTYPE2.EQ.3) GO TO 109                                         CAEOS  2090
108   CONTINUE                                                          CAEOS  2100
      GO TO 117                                                         CAEOS  2110
C                                                                       CAEOS  2120
C                                                                       CAEOS  2130
C***********************************************************************CAEOS  2140
C*                                                                     *CAEOS  2150
C* IF NO CAE SOLUTION EXISYS FOR CURRENT VALUE OF M4, INCREMENT M4 AND *CAEOS  2160
C* SEARCH FOR SOLUTION.  IF SOLUTION FOUND, TEST FOR MINIMUM XWPWS AND *CAEOS  2170
C* INCREMENT M4.                                                       *CAEOS  2180
C*                                                                     *CAEOS  2190
C***********************************************************************CAEOS  2200
C                                                                       CAEOS  2210
C                                                                       CAEOS  2220
109   XWPWS=1.0/WSWP                                                    CAEOS  2230
      CALL MIN(M4,XWPWS,NTYPE1,NIT1,FAIL)                               CAEOS  2240
      IF(FAIL.EQ.YES) GO TO 115                                         CAEOS  2250
      IF(NTYPE1.EQ.4) GO TO 111                                         CAEOS  2260
110   CONTINUE                                                          CAEOS  2270
      GO TO 118                                                         CAEOS  2280
111   WPWS=XWPWS                                                        CAEOS  2290
```

```
      P5P4=1.0/P4P5                                                     CAEOS  2300
      P60P50=P6P5*P0PM(GM,M6)/P0PM(GP,M5)                               CAEOS  2310
      T5T4=T50T40*T0TM(GS,M4)/T0TM(GP,M5)                               CAEOS  2320
      T6T5=T60T50*T0TM(GP,M5)/T0TM(GM,M6)                               CAEOS  2330
      RETURN                                                            CAEOS  2340
C                                                                       CAEOS  2350
C                                                                       CAEOS  2360
C*******************************************************************CAEOS  2370
C*                                                                 *CAEOS  2380
C*                         FAILURE INDICATORS                      *CAEOS  2390
C*                                                                 *CAEOS  2400
C*******************************************************************CAEOS  2410
C                                                                       CAEOS  2420
C                                                                       CAEOS  2430
112   WRITE(6,201)                                                      CAEOS  2440
      RETURN                                                            CAEOS  2450
113   WRITE(6,202)                                                      CAEOS  2460
      RETURN                                                            CAEOS  2470
114   WRITE(6,203)                                                      CAEOS  2480
      RETURN                                                            CAEOS  2490
115   WRITE(6,204)                                                      CAEOS  2500
      RETURN                                                            CAEOS  2510
116   WRITE(6,205)M4,A6A5,M5,XP7P40,P7P40                               CAEOS  2520
      GO TO 119                                                         CAEOS  2530
117   WRITE(6,206,M4,M5,A6A5,XP50P40,P50P40                             CAEOS  2540
      GO TO 119                                                         CAEOS  2550
118   WRITE(6,207)M5,A6A5,M4,XWPHS                                      CAEOS  2560
119   FAIL=YES                                                          CAEOS  2570
C                                                                       CAEOS  2580
C                                                                       CAEOS  2590
C*******************************************************************CAEOS  2600
C*                                                                 *CAEOS  2610
C*                         FORMAT STATEMENTS                       *CAEOS  2620
C*                                                                 *CAEOS  2630
C*******************************************************************CAEOS  2640
C                                                                       CAEOS  2650
C                                                                       CAEOS  2660
201   FORMAT(*0*,T2,*PROGRAM TERMINATED IN SUBROUTINE CAEFC*,/,         CAEOS  2670
     -T2,*AS CALLED FROM SUBROUTINE CAEOS*)                             CAEOS  2680
202   FORMAT(*0*,T2,*PROGRAM TERMINATED IN SUBROUTINE CAEOCV*,/,        CAEOS  2690
     -T2,*AS CALLED FROM SUBROUTINE CAEOS*)                             CAEOS  2700
203   FORMAT(*0*,T2,*PROGRAM TERMINATED IN SUBROUTINE SDS*,/,           CAEOS  2710
     -T2,*AS CALLED FROM SUBROUTINE CAEOS*)                             CAEOS  2720
204   FORMAT(*0*,T2,*PROGRAM TERMINATED IN SUBROUTINE MIN*,/,           CAEOS  2730
     -T2,*AS CALLED FROM SUBROUTINE CAEOS*)                             CAEOS  2740
205   FORMAT(*0*,T2,*CONVERGENCE FAILURE IN SUBROUTINE CAEOS*,/,        CAEOS  2750
     -T2,*FOR M5 SUCH THAT XP7P40=P7P40*,//,                            CAEOS  2760
     -T2,*M4       =*,E13.6,T26,*A6A5    =*,E13.6,/,                    CAEOS  2770
     -T2,*M5       =*,E13.6,T26,*XP7P40 =*,E13.5,/,                     CAEOS  2780
     -T2,*P7P40   =*,E13.6)                                             CAEOS  2790
206   FORMAT(*0*,T2,*CONVERGENCE FAILURE IN SUBROUTINE CAEOS*,/,        CAEOS  2800
     -T2,*FOR A6A5 SUCH THAT XP50P40=P50P40*,//,                        CAEOS  2810
     -T2,*M4       =*,E13.6,T26,*M5      =*,E13.6,/,                    CAEOS  2820
     -T2,*A6A5    =*,E13.6,T26,*XP50P40=*,E13.5,/,                      CAEOS  2830
     -T2,*P50P40 =*,E13.6)                                              CAEOS  2840
```

```
207   FORMAT(*0*,T2,*CONVERGFNCE FAILURF IN SURROUTINE CAEOS*,/,          CAEOS  2850
     -T2,*FOR M4 SUCH THAT XWPWS = MINIMUM WPWS*,//,                      CAEOS  2860
     -T2,*M5       =*,E13.6,T26,*A6A5    =*,E13.6,/,                      CAEOS  2870
     -T2,*M4       =*,E13.6,T26,*XWPWS   =*,F13.6)                        CAEOS  2880
      FND                                                                 CAEOS  2890
```

```
      SUBROUTINE INPRS                                                  INPRS 0100
C                                                                       INPRS 0110
C                                                                       INPRS 0120
C***********************************************************************INPRS 0130
C*                                                                     *INPRS 0140
C*                           INPUT SUBROUTINE (INPRS)                  *INPRS 0150
C*                                                                     *INPRS 0160
C***********************************************************************INPRS 0170
C                                                                       INPRS 0180
C***********************************************************************INPRS 0190
C*                                                                     *INPRS 0200
C*    SUBROUTINE INPRS CONTROLS THE INPUT OF INITIAL DATA FOR THE      *INPRS 0210
C*    PRESSURE RECOVERY SECTION.                                       *INPRS 0220
C*                                                                     *INPRS 0230
C* INPUT/OUTPUT VARIABLES:                                             *INPRS 0240
C*                                                                     *INPRS 0250
C* A3A2    = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE AREA RATIO             *INPRS 0260
C* A7A6    = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE AREA RATIO             *INPRS 0270
C* EJECT   = CONTROL VARIABLE SUCH THAT:                               *INPRS 0280
C*         = "NO"  FOR NO PRESSURE RECOVERY SUBSYSTEM                  *INPRS 0290
C*         = "DIF" FOR A SUPERSONIC-SUBSONIC DIFFUSER SUBSYSTEM        *INPRS 0300
C*         = "CAE" FOR A CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR    *INPRS 0310
C*           SUBSYSTEM                                                 *INPRS 0320
C*         = "SSE" FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR  *INPRS 0330
C*           SUBSYSTEM                                                 *INPRS 0340
C* ETA12   = NORMAL SHOCK DIFFUSER COEFFICIENT                         *INPRS 0350
C* G5      = PRIMARY STREAM GAMMA                                      *INPRS 0360
C* LIMIT   = SUPERSONIC-SUPERSONIC EJECTOR CONTROL VARIABLE SUCH THAT: *INPRS 0370
C*         = "ULP" FOR THE UPPER LIMIT POINT                           *INPRS 0380
C*         = "ZSP" FOR THE ZUKOSKI SEPARATION POINT                    *INPRS 0390
C*         = "MPP" FOR THE MATCHED PRESSURE POINT                      *INPRS 0400
C* MW5     = PRIMARY STREAM MOLECULAR WEIGHT (KG/KMOLE)                 *INPRS 0410
C* PRSS1   = CONTROL VARIABLE                                          *INPRS 0420
C* PRSS2   = CONTROL VARIABLE                                          *INPRS 0430
C* P50     = PRIMARY STREAM STAGNATION PRESSURE (PA)                   *INPRS 0440
C* P7      = AMBIENT PRESSURE (PA)                                     *INPRS 0450
C* SETPRS  = CONTROL VARIABLE                                          *INPRS 0460
C*                                                                     *INPRS 0470
C* NOTE: ALL INPUT IS IN SI UNITS.                                     *INPRS 0480
C*                                                                     *INPRS 0490
C***********************************************************************INPRS 0500
C                                                                       INPRS 0510
C                                                                       INPRS 0520
      IMPLICIT REAL(L,M,N)                                              INPRS 0530
C                                                                       INPRS 0540
      COMMON/MAIN5/SETPRS                                               INPRS 0550
C                                                                       INPRS 0560
      COMMON/PRS1/PRSS1                                                 INPRS 0570
C                                                                       INPRS 0580
      COMMON/PRS3/A3A2,A7A6,ETA12,LIMIT,MW5,P7,T50                      INPRS 0590
C                                                                       INPRS 0600
      COMMON/PRS5/EJECT                                                 INPRS 0610
C                                                                       INPRS 0620
      COMMON/PRS6/G5,P50                                                INPRS 0630
C                                                                       INPRS 0640
```

```
      DATA CAE/3HCAE/,NO/2HNO/,SSE/3HSSE/                               INPRS  0650
C                                                                       INPRS  0660
      NAMELIST/NLPRS/A3A2,A7A6,ETA12,G5,MW5,P50,P7,T50                  INPRS  0670
C                                                                       INPRS  0680
C                                                                       INPRS  0690
C***********************************************************************INPRS  0700
C*                                                                     *INPRS  0710
C*                          SET DEFAULT VALUES                         *INPRS  0720
C*                                                                     *INPRS  0730
C***********************************************************************INPRS  0740
C                                                                       INPRS  0750
C                                                                       INPRS  0760
      IF(SETPRS.EQ.NO) GO TO 101                                        INPRS  0770
      A3A2=3.0                                                          INPRS  0780
      A7A6=3.0                                                          INPRS  0790
      EJECT=CAE                                                         INPRS  0800
      ETA12=0.75                                                        INPRS  0810
      G5=1.29                                                           INPRS  0820
      LIMIT=3HZSP                                                       INPRS  0830
      MW5=20.204                                                        INPRS  0840
      P50=3.10264E+06                                                   INPRS  0850
      P7=1.01325E+05                                                    INPRS  0860
      T50=2.8148E+03                                                    INPRS  0870
      SETPRS=NO                                                         INPRS  0880
C                                                                       INPRS  0890
C                                                                       INPRS  0900
C***********************************************************************INPRS  0910
C*                                                                     *INPRS  0920
C*                          CONTROL STATEMENTS                         *INPRS  0930
C*                                                                     *INPRS  0940
C***********************************************************************INPRS  0950
C                                                                       INPRS  0960
C                                                                       INPRS  0970
101   WRITE(6,201)                                                      INPRS  0980
      READ(5,202)PRSS1                                                  INPRS  0990
      IF(PRSS1.EQ.NO) RETURN                                            INPRS  1000
      WRITE(6,203)                                                      INPRS  1010
      READ(5,202)PRSS2                                                  INPRS  1020
      IF(PRSS2.EQ.NO) GO TO 102                                         INPRS  1030
      REWIND 3                                                          INPRS  1040
      READ(3)A3A2,A7A6,EJECT,ETA12,G5,LIMIT,MW5,P50,P7,T50              INPRS  1050
      RETURN                                                            INPRS  1060
102   WRITE(6,204)                                                      INPRS  1070
      READ(5,202)EJECT                                                  INPRS  1080
      IF(EJECT.EQ.NO) RETURN                                            INPRS  1090
      IF(EJECT.EQ.CAE) GO TO 103                                        INPRS  1100
      IF(EJECT.EQ.SSE) GO TO 104                                        INPRS  1110
      WRITE(6,205)                                                      INPRS  1120
      WRITE(6,206)A3A2,ETA12                                            INPRS  1130
      GO TO 105                                                         INPRS  1140
103   WRITE(6,205)                                                      INPRS  1150
      WRITE(6,207)A3A2,A7A6,ETA12,G5,MW5,P50,P7,T50                     INPRS  1160
      GO TO 105                                                         INPRS  1170
104   WRITE(6,208)                                                      INPRS  1180
      READ(5,202)LIMIT                                                  INPRS  1190
```

```
      WRITE(6,205)                                                      INPRS  1200
      WRITE(6,209)A7A6,G5,MW5,P50,P7,T50                                INPRS  1210
105   READ(5,NLPRS)                                                     INPRS  1220
      REWIND 3                                                          INPRS  1230
      WRITE(3)A3A2,A7A6,EJECT,ETA12,G5,LIMIT,MW5,P50,P7,T50             INPRS  1240
C                                                                       INPRS  1250
C                                                                       INPRS  1260
C***********************************************************************INPRS  1270
C*                                                                     *INPRS  1280
C*                           FORMAT STATEMENTS                         *INPRS  1290
C*                                                                     *INPRS  1300
C***********************************************************************INPRS  1310
C                                                                       INPRS  1320
C                                                                       INPRS  1330
201   FORMAT(*1*,T2,*ARE NEW PRESSURE RECOVERY SECTION INPUTS REQUIRED?*INPRS  1340
     -,/)                                                               INPRS  1350
202   FORMAT(A3)                                                        INPRS  1360
203   FORMAT(*0*,T2,*SHOULD INPUT DATA BE READ FROM TAPE3?*,/)          INPRS  1370
204   FORMAT(*1*,T2,*INPUT THE PRESSURE RECOVERY SUBSYSTEM FROM THE FOLLINPRS  1380
     -OWING LIST:*,//,T2,*"NO"  FOR NO PRESSURE RECOVERY SUBSYSTEM*,/,T2INPRS  1390
     -,*"DIF" FOR A SUPERSONIC-SUBSONIC DIFFUSER SUBSYSTEM*,/,T2,*"CAE" INPRS  1400
     -FOR A CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SUBSYSTEM*,/,T2,*INPRS  1410
     -"SSE" FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR SUBSYSTEMINPRS  1420
     -*,/)                                                              INPRS  1430
205   FORMAT(*1*,T2,*INPUT DATA FOR THE PRESSURE RECOVERY SECTION BY NAMINPRS  1440
     -ELIST.*,/,T2,*CURRENT VALUES ARE:*)                               INPRS  1450
206   FORMAT(* *,T2,*$NLPRS*,T26,*A3A2     =*,E13.6,T50,*ETA12    =*,   INPRS  1460
     -E13.6,* $*,/)                                                     INPRS  1470
207   FORMAT(* *,T2,*$NLPRS*,T26,*A3A2     =*,E13.6,T50,*A7A6     =*,   INPRS  1480
     -E13.6,/,T2,*ETA12    =*,E13.6,T26,*G5       =*,E13.6,T50,         INPRS  1490
     -*MW5     =*,E13.6,/,T2,*P50     =*,E13.6,T26,*P7       =*,E13.6,  INPRS  1500
     -T50,*T50      =*,E13.6,* $*,/)                                    INPRS  1510
208   FORMAT(*1*,T2,*INPUT THE LIMITING CONDITION FOR THE SUPERSONIC-SUPINPRS  1520
     -ERSONIC EJECTOR FROM THE*,/,T2,*FOLLOWING LIST:*,//,T2,*"ULP" FOR INPRS  1530
     -THE UPPER LIMIT POINT*,/,T2,*"ZSP" FOR THE ZUKOSKI SEPARATION POININPRS  1540
     -T*,/,T2,*"MPP" FOR THE MATCHED PRESSURE POINT*,/)                 INPRS  1550
209   FORMAT(* *,T2,*$NLPRS*,T26,*A7A6     =*,E13.6,T50,*G5       =*,   INPRS  1560
     -E13.6,/,T2,*MW5     =*,E13.6,T26,*P50      =*,E13.6,T50,          INPRS  1570
     -*P7      =*,E13.6,/,T2,*T50      =*,E13.6,* $*,/)                 INPRS  1580
      END                                                               INPRS  1590
```

```
      SUBROUTINE ITER(X,DX,ERRORX,SIGN,Y,YGIVEN,ERRORY,NIT,
     -NTYPE,XNEG,YNEG,XPOS,YPOS,NSIGN1,NSIGN2)
C
C
C***********************************************************************
C*                                                                     *
C*                    ITERATION SUBROUTINE (ITER)                      *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C* SUBROUTINE  ITER  PERFORMS AN  ITERATION TO  FIND X SUCH  THAT  THE *
C* PERCENT  ERROR  IN Y AND  YGIVEN IS .LE. TO  ERRORY OR  THE PERCENT *
C* DEVIATION IN X(I+1) AND X(I) IS .LE. TO ERRORX.                     *
C*       IS .LE. TO ERRORX.                                            *
C*                                                                     *
C* INPUT VARIABLES:                                                    *
C*                                                                     *
C* DX     = INCREMENT IN INDEPENDENT VARIABLE                          *
C* ERRORX = MAX PERCENT DEVIATION IN X(I+1) AND X(I) FOR SOLUTION      *
C* ERRORY = MAX PERCENT ERROR IN Y AND YGIVEN FOR SOLUTION             *
C* SIGN   = +1.0 OR -1.0, +/- INCREMENTING FROM INITIAL X              *
C* Y      = DEPENDENT VARIABLE                                         *
C* YGIVEN = GIVEN VALUE OF DEPENDENT VARIABLE                          *
C*                                                                     *
C* INPUT/OUTPUT VARIABLES:                                             *
C*                                                                     *
C* NIT    = ITERATION NUMBER                                           *
C* NTYPE  = 1--INCREMENT, 2--INTERPOLATION, 3--SOLUTION                *
C* X      = INDEPENDENT VARIABLE                                       *
C*                                                                     *
C* NOTE: THE  INTERMEDIATE  VARIABLES  XNEG, YNEG, XPOS, YPOS, NSIGN1, *
C*       NSIGN2 MUST BE STORED BETWEEN ITERATIONS.                     *
C*                                                                     *
C***********************************************************************
C
C
      ERROR(ACTUAL,GIVEN)=(ACTUAL-GIVEN)*100.0/GIVEN
C
      IF(ABS(ERROR(Y,YGIVEN))-ERRORY) 90,90,10
   10 IF(Y-YGIVEN) 20,90,30
   20 NSIGN2=-1
      XNEG=X
      YNEG=Y
      GO TO 40
   30 NSIGN2=+1
      XPOS=X
      YPOS=Y
   40 GO TO (50,80), NTYPE
   50 IF(NIT-1) 70,70,60
   60 NSIGN=NSIGN1*NSIGN2
      IF(NSIGN) 80,80,70
   70 NSIGN1=NSIGN2
      NIT=NIT+1
```

```
C                                                                       ITER   0650
C                                                                       ITER   0660
C***********************************************************************ITER   0670
C*                                                                     *ITER   0680
C*                INCREMENT TO FIND SOLUTION INTERVAL                  *ITER   0690
C*                                                                     *ITER   0700
C***********************************************************************ITER   0710
C                                                                       ITER   0720
C                                                                       ITER   0730
      X=X+SIGN*DX                                                       ITER   0740
      GO TO 100                                                         ITER   0750
C                                                                       ITER   0760
C                                                                       ITER   0770
C***********************************************************************ITER   0780
C*                                                                     *ITER   0790
C*                      INTERPOLATION FOR SOLUTION                     *ITER   0800
C*                                                                     *ITER   0810
C***********************************************************************ITER   0820
C                                                                       ITER   0830
C                                                                       ITER   0840
   80 NTYPE=2                                                           ITER   0850
      NIT=NIT+1                                                         ITER   0860
      XSAVE=X                                                           ITER   0870
      RATIO=(XPOS-XNEG)/(YPOS-YNEG)                                     ITER   0880
      X=XNEG+RATIO*(YGIVEN-YNEG)                                        ITER   0890
      IF(ABS(ERROR(X,XSAVE))-ERRORX) 90,90,100                          ITER   0900
   90 NTYPE=3                                                           ITER   0910
  100 END                                                               ITER   0920
```

```
      SUBROUTINE MAAS(G,MINI,AAS,FLOW,ERROR,MNEW,FAIL)                  MAAS   0100
C                                                                       MAAS   0110
C                                                                       MAAS   0120
C***********************************************************************MAAS   0130
C*                                                                     *MAAS   0140
C*                         SUBROUTINE (MAAS)                           *MAAS   0150
C*                                                                     *MAAS   0160
C***********************************************************************MAAS   0170
C                                                                       MAAS   0180
C***********************************************************************MAAS   0190
C*                                                                     *MAAS   0200
C* SUBROUTINE MASS CALCULATES THE MACH NUMBER (M) GIVEN THE AREA RATIO *MAAS   0210
C* (A/A*) BY LINEAR ITERATION.                                         *MAAS   0220
C*                                                                     *MAAS   0230
C* INPUT VARIABLES:                                                    *MAAS   0240
C*                                                                     *MAAS   0250
C* AAS    = THE AREA RATIO A/A*                                        *MAAS   0260
C* ERROR  = MAX PERCENT DEVIATION IN MOLD AND MNEW FOR A SOLUTION      *MAAS   0270
C* FLOW   = CONTROL VARIALBE SUCH THAT:                                *MAAS   0280
C*        = "SUB" FOR THE SUBSONIC BRANCH                              *MAAS   0290
C*        = "SUP" FOR THE SUPERSONIC BRANCH                            *MAAS   0300
C* G      = SPECIFIC HEAT RATIO                                        *MAAS   0310
C* MINI   = INITIAL VALUE OF MACH NUMBER                                *MAAS   0320
C*                                                                     *MAAS   0330
C* OUTPUT VARIABLES:                                                   *MAAS   0340
C*                                                                     *MAAS   0350
C* FAIL   = ERROR FLAG                                                 *MAAS   0360
C* MNEW   = FINAL VALUE OF MACH NUMBER                                  *MAAS   0370
C*                                                                     *MAAS   0380
C***********************************************************************MAAS   0390
C                                                                       MAAS   0400
C                                                                       MAAS   0410
      IMPLICIT REAL(M)                                                  MAAS   0420
      DATA YES/3HYES/,SUP/3HSUP/                                        MAAS   0430
C                                                                       MAAS   0440
C                                                                       MAAS   0450
C***********************************************************************MAAS   0460
C*                                                                     *MAAS   0470
C*                        CALCULATE CONSTANTS                          *MAAS   0480
C*                                                                     *MAAS   0490
C***********************************************************************MAAS   0500
C                                                                       MAAS   0510
C                                                                       MAAS   0520
      G1=(G-1.0)/2.0                                                    MAAS   0530
      G1I=1.0/G1                                                        MAAS   0540
      G2=2.0/(G+1.0)                                                    MAAS   0550
      G2I=1.0/G2                                                        MAAS   0560
      G4=(G+1.0)/(2.0*(G-1.0))                                          MAAS   0570
      G4I=1.0/G4                                                        MAAS   0580
C                                                                       MAAS   0590
C                                                                       MAAS   0600
C***********************************************************************MAAS   0610
C*                                                                     *MAAS   0620
C*                  CALCULATE THE SUPERSONIC BRANCH                    *MAAS   0630
C*                                                                     *MAAS   0640
```

```
C***********************************************************************
C
C
      MOLD=MINI
      IF(FLOW.NE.SUP) GO TO 2
      DO 1 J=1,200
      C1=(MOLD*AAS)**G4I
      MNEW=SQRT(G1I*(G2I*C1-1.0))
      XERROR=(MNEW-MOLD)*100.0/MOLD
      MOLD=MNEW
      IF(ABS(XERROR).LT.ERROR) RETURN
1     CONTINUE
      GO TO 4
C
C
C***********************************************************************
C*                                                                    *
C*                    CALCULATE THE SUBSONIC BRANCH                   *
C*                                                                    *
C***********************************************************************
C
C
2     DO 3 J=1,200
      C1=1.0+G1*MOLD*MOLD
      MNEW=((G2*C1)**G4)/AAS
      XERROR=(MNEW-MOLD)*100.0/MOLD
      MOLD=MNEW
      IF(ABS(XERROR).LT.ERROR) RETURN
3     CONTINUE
C
C
C***********************************************************************
C*                                                                    *
C*                         CONVERGENCE FAILURE                        *
C*                                                                    *
C***********************************************************************
C
C
4     WRITE(6,5)FLOW,G,MINI,MNEW,AAS,XERROR,ERROR
      FAIL=YES
5     FORMAT(*1*,T2,*CONVERGENCE FAILURE FOR *,A3,*SONIC *,
     -*BRANCH IN SUBROUTINE MAAS*,/,
     -T2,*G      =*,E13.6,2X,*MINI   =*,E13.6,/,
     -T2,*MNEW   =*,E13.6,2X,*AAS    =*,E13.6,/,
     -T2,*XERROR =*,E13.6,2X,*ERROR  =*,E13.6)
      END
```

```
      SUBROUTINE MIN(MS1,FUNC,NTYPE,NIT,FAIL)
C
C
C***********************************************************************
C*                                                                     *
C*                   MINIMIZATION SUBROUTINE (MIN)                     *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C* SUBROUTINE MIN, AS APPLIED TO A  CONSTANT-AREA, SUBSONIC-SUPERSONIC *
C* EJECTOR, PERFORMS A SEARCH  AND INTERVAL HALVING  PROCEDURE TO FIND *
C* MS1 SUCH THAT FUNC(MS1) IS A MINIMUM.                               *
C*                                                                     *
C* INPUT VARIABLES:                                                    *
C*                                                                     *
C* FUNC    = FUNCTION OF MS1                                           *
C*                                                                     *
C* INPUT/OUTPUT VARIABLES:                                             *
C*                                                                     *
C* MS1     = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE            *
C* NIT     = ITERATION NUMBER                                          *
C* NTYPE   = 1,2 - SEARCH                                              *
C*         = 3,4 - SOLUTION                                            *
C*                                                                     *
C* OUTPUT VARIABLES:                                                   *
C*                                                                     *
C* FAIL    = ERROR FLAG                                                *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
      REAL NO
      DATA DX,XLOW,XERROR,YERROR/0.1,1.0E-03,0.025,1.0/
      DATA YES/3HYES/,NO/2HNO/,PART/4HPART/
C
      ERROR(ACTUAL,GIVEN)=(ACTUAL-GIVEN)*100.0/GIVEN
C
C
C***********************************************************************
C*                                                                     *
C*              NO CAE SOLUTION EXITS FOR CURRENT  VALUE OF            *
C*              MS1.  INCREMENT MS1 AND SEARCH FOR SOLUTION.           *
C*                                                                     *
C***********************************************************************
C
C
      IF(FAIL.NE.PART) GO TO 100
      MS1=MS1-XERROR
      IF(MS1.LT.XLOW) GO TO 108
      FAIL=NO
      RETURN
100   IF(NIT.NE.1) GO TO 101
```

```
      DMS1=DX                                                           MIN     0650
      MS1LOW=XLOW                                                       MIN     0660
101   NIT=NIT+1                                                         MIN     0670
      GO TO (102,104,107),NTYPE                                         MIN     0680
C                                                                       MIN     0690
C                                                                       MIN     0700
C***********************************************************************MIN     0710
C*                                                                     *MIN     0720
C*                     STORE UPPER BOUND FOR MS1                       *MIN     0730
C*                                                                     *MIN     0740
C***********************************************************************MIN     0750
C                                                                       MIN     0760
C                                                                       MIN     0770
102   X1=MS1                                                            MIN     0780
      Y1=FUNC                                                           MIN     0790
103   MS1=MS1-DMS1                                                      MIN     0800
      IF(MS1.LT.MS1LOW) GO TO 108                                       MIN     0810
      NTYPE=2                                                           MIN     0820
      RETURN                                                            MIN     0830
C                                                                       MIN     0840
C                                                                       MIN     0850
C***********************************************************************MIN     0860
C*                                                                     *MIN     0870
C*                     STORE LOWER BOUND FOR MS1                       *MIN     0880
C*                                                                     *MIN     0890
C***********************************************************************MIN     0900
C                                                                       MIN     0910
C                                                                       MIN     0920
104   X2=MS1                                                            MIN     0930
      Y2=FUNC                                                           MIN     0940
      IF(Y2.GT.Y1) GO TO 105                                            MIN     0950
      GO TO 102                                                         MIN     0960
C                                                                       MIN     0970
C                                                                       MIN     0980
C***********************************************************************MIN     0990
C*                                                                     *MIN     1000
C*              TEST FUNC FOR MINIMUM AND INTERVAL HALVE               *MIN     1010
C*                                                                     *MIN     1020
C***********************************************************************MIN     1030
C                                                                       MIN     1040
C                                                                       MIN     1050
105   IF(ABS(ERROR(Y2,Y1)).LE.YERROR) GO TO 106                         MIN     1060
      DMS1=DMS1/2.0                                                     MIN     1070
      IF(DMS1.LT.XERROR) GO TO 106                                      MIN     1080
      MS1LOW=X2                                                         MIN     1090
      MS1=X1                                                            MIN     1100
      GO TO 103                                                         MIN     1110
C                                                                       MIN     1120
C                                                                       MIN     1130
C***********************************************************************MIN     1140
C*                                                                     *MIN     1150
C*       MS1 FOR MIN FUNC HAS BEEN FOUND BUT SOLUTION WAS LOST         *MIN     1160
C*                                                                     *MIN     1170
C***********************************************************************MIN     1180
C                                                                       MIN     1190
```

```
C
106   IF(Y2.LE.Y1) GO TO 107
      MS1=X1
      NTYPE=3
      RETURN
C
C
C***********************************************************************
C*                                                                     *
C*        MS1 FOR MIN FUNC HAS BEEN FOUND AND SOLUTION SAVED           *
C*                                                                     *
C***********************************************************************
C
C
107   NTYPE=4
      RETURN
C
C
C***********************************************************************
C*                                                                     *
C*               SEARCH FAILURE: NO CAE SOLUTION FOUND                 *
C*                                                                     *
C***********************************************************************
C
C
108   WRITE(6,201)MS1,MS1LOW,DMS1
      FAIL=YES
C
C
C***********************************************************************
C*                                                                     *
C*                         FORMAT STATEMENTS                           *
C*                                                                     *
C***********************************************************************
C
C
201   FORMAT(*1*,T2,*MS1 =*,E13.6,2X,*BELOW LOWER LIMIT MS1 =*,
     -E13.6,/,T2,*FOR DMS1 =*,E13.6)
      END
```

```
      SUBROUTINE NSDS(G,M1,RD,M2,P2P1,P20P10,T2T1,T20T10)
C
C
C***********************************************************************
C*                                                                     *
C*               NORMAL SHOCK DIFFUSER SUBROUTINE (NSDS)               *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C* SUBROUTINE  NSDS CALCULATES  THE PRESSURE  RATIO ACROSS A CONSTANT- *
C* AREA, SUPERSONIC  DIFFUSER.  THE STATIC  PRESSURE RATIO IS TAKEN AS *
C* RD*(PY/PX)  FOR A NORMAL  SHOCK AT  THE ENTERING  MACH NUMBER.  ALL *
C* OTHER PROPERTIES ARE CALCULATED FROM THE ISENTROPIC  FLOW RELATIONS *
C* TO BE CONSISTENT WITH THE ENTRANCE AND EXIT MACH NUMBERS.           *
C*                                                                     *
C* INPUT VARIABLES:                                                    *
C*                                                                     *
C* G      = GAMMA                                                      *
C* M1     = ENTRANCE MACH NUMBER                                       *
C* RD     = NORMAL SHOCK DIFFUSER COEFFICIENT                          *
C*                                                                     *
C* OUTPUT VARIABLES:                                                   *
C*                                                                     *
C* M2     = EXIT MACH NUMBER                                           *
C* P2P1   = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO                     *
C* P20P10 = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO                 *
C* T2T1   = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO                  *
C* T20T10 = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO              *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
C
      T0TM(GX,MX)=1.0+0.5*(GX-1.0)*MX*MX
      P0PM(GX,MX)=(1.0+0.5*(GX-1.0)*MX*MX)**(GX/(GX-1.0))
C
      M2=SQRT((2.0+(G-1.0)*M1*M1)/(2.0*G*M1*M1-G+1.0))
      P2P1=RD*(2.0*G*M1*M1-G+1.0)/(G+1.0)
      P10P1=P0PM(G,M1)
      P20P2=P0PM(G,M2)
      P20P10=P20P2*P2P1/P10P1
      T20T10=1.0
      T10T1=T0TM(G,M1)
      T20T2=T0TM(G,M2)
      T2T1=T10T1*T20T10/T20T2
      END
```

```
      SUBROUTINE OUTPRS
C
C
C***********************************************************************
C*                                                                     *
C*                      OUTPUT SUBROUTINE (OUTPRS)                     *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C*  SUBROUTINE OUTPRS PRINTS THE PRESSURE RECOVERY SECTION RESULTS OF  *
C*  PROGRAM  CLAP IN SI  UNITS ON  TERMINALS  WITH A  MINIMUM OF  132  *
C*  CHARATERS PER LINE,                                                *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(L,M)
C
      COMMON/LDS4/A1,G1,MW1,M1,P1,P10,R1,R10,T1,T10
C
      COMMON/PRS2/A2,A3,A4,A7,ETA23,ETA67,G2,G3,G4,G6,G7,MW2,MW3,MW4,
     -MW6,MW7,M2,M3,M4,M6,M7,P2,P20,P3,P30,P4,P40,P5,P6,P60,P70,R2,R20,
     -R3,R30,R4,R40,R5,R50,R6,R60,R7,R70,T2,T20,T3,T30,T4,T40,T5,T6,T60,
     -T7,T70,W2W1,W3W1,W4W1,W6W1,W7W1,X2X1,X3X1,X4X1,X5X1,X6X1,X7X1
C
      COMMON/PRS3/A3A2,A7A6,ETA12,LIMIT,MW5,P7,T50
C
      COMMON/PRS4/A5,A6,M5,W5W1
C
      COMMON/PRS5/EJECT
C
      COMMON/PRS6/G5,P50
C
      DATA CAE/3HCAE/,MPP/3HMPP/,SSE/3HSSE/,ULP/3HULP/,Z3P/3HZ3P/
C
C
C***********************************************************************
C*                                                                     *
C*                         OUTPUT INITIAL DATA                         *
C*                                                                     *
C***********************************************************************
C
C
      WRITE(20,201)
      IF(EJECT.EQ.CAE) GO TO 101
      IF(EJECT.EQ.SSE) GO TO 102
      WRITE(20,202)A3A2,EJECT,ETA12
      WRITE(20,205)
      GO TO 103
101   WRITE(20,203)A3A2,A7A6,EJECT,ETA12,G5,MW5,P50,P7,T50
      WRITE(20,205)
      GO TO 103
102   WRITE(20,204)A7A6,EJECT,G5,LIMIT,MW5,P50,P7,T50
```

```
      WRITE(20,206)                                                     OUTPRS 0650
C                                                                       OUTPRS 0660
C                                                                       OUTPRS 0670
C***********************************************************************OUTPRS 0680
C*                                                                     *OUTPRS 0690
C*                         OUTPUT RESULTANT DATA                       *OUTPRS 0700
C*                                                                     *OUTPRS 0710
C***********************************************************************OUTPRS 0720
C                                                                       OUTPRS 0730
C                                                                       OUTPRS 0740
103   WRITE(20,207)A1,G1,MW1,M1,P1,P10,R1,R10,T1,T10                    OUTPRS 0750
      IF(EJECT.EQ.SSE) GO TO 104                                        OUTPRS 0760
      WRITE(20,208)A2,ETA12,G2,MW2,M2,P2,P20,R2,R20,T2,T20,W2W1,X2X1    OUTPRS 0770
      WRITE(20,209)                                                     OUTPRS 0780
      IF(EJECT.EQ.CAE) WRITE(20,210)                                    OUTPRS 0790
      WRITE(20,211)A3,ETA23,G3,MW3,M3,P3,P30,R3,R30,T3,T30,W3W1,X3X1    OUTPRS 0800
      IF(EJECT.NE.CAE) RETURN                                           OUTPRS 0810
      WRITE(20,212)A4,G4,MW4,M4,P4,P40,R4,R40,T4,T40,W4W1,X4X1          OUTPRS 0820
      WRITE(20,213)                                                     OUTPRS 0830
      GO TO 105                                                         OUTPRS 0840
104   IF(LIMIT.EQ.ULP) WRITE(20,214)                                    OUTPRS 0850
      IF(LIMIT.EQ.ZSP) WRITE(20,215)                                    OUTPRS 0860
      IF(LIMIT.EQ.MPP) WRITE(20,216)                                    OUTPRS 0870
      WRITE(20,217)                                                     OUTPRS 0880
105   WRITE(20,218)A5,G5,MW5,M5,P5,P50,R5,R50,T5,T50,W5W1,X5X1          OUTPRS 0890
      IF(EJECT.EQ.CAE) WRITE(20,219)                                    OUTPRS 0900
      IF(EJECT.EQ.SSE) WRITE(20,220)                                    OUTPRS 0910
      WRITE(20,221)A6,G6,MW6,M6,P6,P60,R6,R60,T6,T60,W6W1,X6X1          OUTPRS 0920
      WRITE(20,222)A7,ETA67,G7,MW7,M7,P7,P70,R7,R70,T7,T70,W7W1,X7X1    OUTPRS 0930
C                                                                       OUTPRS 0940
C                                                                       OUTPRS 0950
C***********************************************************************OUTPRS 0960
C*                                                                     *OUTPRS 0970
C*                          FORMAT STATEMENTS                          *OUTPRS 0980
C*                                                                     *OUTPRS 0990
C***********************************************************************OUTPRS 1000
C                                                                       OUTPRS 1010
C                                                                       OUTPRS 1020
201   FORMAT(*1*,T54,*PRESSURE RECOVERY SECTION*,//,T60,*INITIAL DATA*)OUTPRS 1030
202   FORMAT(*0*,T32,*A3A2    =*,E13.6,T66,*EJECT    =*,A13,/,          OUTPRS 1040
     -T32,*ETA12   =*,E13.6)                                            OUTPRS 1050
203   FORMAT(*0*,T32,*A3A2    =*,E13.6,T66,*A7A6    =*,E13.6,/,         OUTPRI 1060
     -T32,*EJECT   =*,A13,T66,*ETA12   =*,E13.6,/,                      OUTPRS 1070
     -T32,*G5      =*,E13.6,T66,*MW5     =*,E13.6,* KG/KMOLE*,/,        OUTPRS 1080
     -T32,*P50     =*,E13.6,* PA*,T66,*P7      =*,E13.6,* PA*,/,        OUTPRS 1090
     -T32,*T50     =*,E13.6,* K*)                                       OUTPRS 1100
204   FORMAT(*0*,T32,*A7A6    =*,E13.6,T66,*EJECT    =*,A13,/,          OUTPRS 1110
     -T32,*G5      =*,E13.6,T66,*LIMIT    =*,A13,/,                     OUTPRS 1120
     -T32,*MW5     =*,E13.6,* KG/KMOLE*,T66,*P50     =*,E13.6,* PA*,/,  OUTPRS 1130
     -T32,*P7      =*,E13.6,* PA*,T66,*T50     =*,E13.6,* K*)           OUTPRS 1140
205   FORMAT(*0*,T59,*RESULTANT DATA*,//,T33,*POINT 1  LASER CAVITY EXIOUTPRS 1150
     -T AND NORMAL SHOCK DIFFUSER ENTRANCE*)                            OUTPRS 1160
206   FORMAT(*0*,T59,*RESULTANT DATA*,//,T33,*POINT 1  LASER CAVITY EXIOUTPRS 1170
     -T AND CONSTANT-AREA SUPERSONIC-SUPERSONIC EJECTOR*,/,T32,*SECONDAROUTPRS 1180
     -Y ENTRANCE*)                                                      OUTPRS 1190
```

```
207   FORMAT(*0*,                                                         OUTPRS 1200
     -T32,*A1       =*,E13.6,* S-M2/KMOLE*,T66,*G1        =*,E13.6,/,     OUTPRS 1210
     -T32,*MW1      =*,E13.6,* KG/KMOLE*,T66,*M1        =*,F13.6,/,       OUTPRS 1220
     -T32,*P1       =*,F13.6,* PA*,T66,*P10       =*,F13.6,* PA*,/,       OUTPRS 1230
     -T32,*R1       =*,E13.6,* KG/M3*,T66,*R10       =*,E13.6,* KG/M3*,/, OUTPRS 1240
     -T32,*T1       =*,E13.6,* K*,T66,*T10       =*,E13.6,* K*)           OUTPRS 1250
208   FORMAT(*0*,T23,*POINT 2  NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DOUTPRS 1260
     -IFFUSER ENTRANCE*,//,                                               OUTPRS 1270
     -T32,*A2       =*,E13.6,* S-M2/KMOLE*,T66,*ETA12    =*,E13.6,/,      OUTPRS 1280
     -T32,*G2       =*,E13.6,T66,*MW2       =*,E13.6,* KG/KMOLE*,/,       OUTPRS 1290
     -T32,*M2       =*,E13.6,T66,*P2        =*,E13.6,* PA*,/,             OUTPRS 1300
     -T32,*P20      =*,E13.6,* PA*,T66,*R2         =*,E13.6,* KG/M3*,/,   OUTPRS 1310
     -T32,*R20      =*,E13.6,* KG/M3*,T66,*T2         =*,E13.6,* K*,/,    OUTPRS 1320
     -T32,*T20      =*,E13.6,* K*,T66,*W2W1      =*,F13.6,/,              OUTPRS 1330
     -T32,*X2X1     =*,E13.6)                                             OUTPRS 1340
209   FORMAT(*0*,T23,*POINT 3  SUBSONIC DIFFUSER EXIT *)                  OUTPRS 1350
210   FORMAT(*+*,T55,*AND SUDDEN ENLARGEMENT ENTRANCE*)                   OUTPRS 1360
211   FORMAT(*0*,                                                         OUTPRS 1370
     -T32,*A3       =*,E13.6,* S-M2/KMOLE*,T66,*ETA23    =*,E13.6,/,      OUTPRS 1380
     -T32,*G3       =*,E13.6,T66,*MW3       =*,E13.6,* KG/KMOLE*,/,       OUTPRS 1390
     -T32,*M3       =*,E13.6,T66,*P3        =*,E13.6,* PA*,/,             OUTPRS 1400
     -T32,*P30      =*,E13.6,* PA*,T66,*R3         =*,E13.6,* KG/M3*,/,   OUTPRS 1410
     -T32,*R30      =*,E13.6,* KG/M3*,T66,*T3         =*,E13.6,* K*,/,    OUTPRS 1420
     -T32,*T30      =*,E13.6,* K*,T66,*W3W1      =*,F13.6,/,              OUTPRS 1430
     -T32,*X3X1     =*,E13.6)                                             OUTPRS 1440
212   FORMAT(*0*,T23,*POINT 4  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOOUTPRS 1450
     -R SECONDARY NOZZLE EXIT*,//,                                        OUTPRS 1460
     -T32,*A4       =*,E13.6,* S-M2/KMOLE*,T66,*G4        =*,E13.6,/,     OUTPRS 1470
     -T32,*MW4      =*,E13.6,* KG/KMOLE*,T66,*M4        =*,F13.6,/,       OUTPRS 1480
     -T32,*P4       =*,E13.6,* PA*,T66,*P40       =*,E13.6,* PA*,/,       OUTPRS 1490
     -T32,*R4       =*,E13.6,* KG/M3*,T66,*R40       =*,E13.6,* KG/M3*,/, OUTPRS 1500
     -T32,*T4       =*,E13.6,* K*,T66,*T40       =*,F13.6,* K*,/,         OUTPRS 1510
     -T32,*W4W1     =*,E13.6,T66,*X4X1     =*,E13.6)                      OUTPRS 1520
213   FORMAT(*0*,T23,*POINT 5  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOOUTPRS 1530
     -R PRIMARY NOZZLE EXIT*)                                             OUTPRS 1540
214   FORMAT(*0*,T23,*NOTE:    THE UPPER LIMIT POINT WAS USED AS THE LIMOUTPRS 1550
     -ITING CONDITION FOR*,/,T32,*THE CONSTANT-AREA, SUPERSONIC-SUPERSONOUTPRS 1560
     -IC EJECTOR*)                                                        OUTPRS 1570
215   FORMAT(*0*,T23,*NOTE:    THE ZUKOSKI SEPARATION POINT WAS USED AS OUTPRS 1580
     -THE LIMITING CONDITION FOR*,/,T32,*THE CONSTANT-AREA, SUPERSONIC-SOUTPRS 1590
     -UPERSONIC EJECTOR*)                                                 OUTPRS 1600
216   FORMAT(*0*,T23,*NOTE:    THE MATCHED PRESSURE POINT WAS USED AS THOUTPRS 1610
     -E LIMITING CONDITION FOR*,/,T32,*THE CONSTANT-AREA, SUPERSONIC-SUPOUTPRS 1620
     -ERSONIC EJECTOR*)                                                   OUTPRS 1630
217   FORMAT(*0*,T23,*POINT 5  CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECOUTPRS 1640
     -TOR PRIMARY NOZZLE EXIT*)                                           OUTPRS 1650
218   FORMAT(*0*,                                                         OUTPRS 1660
     -T32,*A5       =*,E13.6,* S-M2/KMOLE*,T66,*G5        =*,E13.6,/,     OUTPRS 1670
     -T32,*MW5      =*,E13.6,* KG/KMOLE*,T66,*M5        =*,E13.6,/,       OUTPRS 1680
     -T32,*P5       =*,E13.6,* PA*,T66,*P50       =*,E13.6,* PA*,/,       OUTPRS 1690
     -T32,*R5       =*,E13.6,* KG/M3*,T66,*R50       =*,E13.6,* KG/M3*,/, OUTPRS 1700
     -T32,*T5       =*,E13.6,* K*,T66,*T50       =*,E13.6,* K*,/,         OUTPRS 1710
     -T32,*W5W1     =*,E13.6,T66,*X5X1     =*,E13.6)                      OUTPRS 1720
219   FORMAT(*1*,T23,*POINT 6  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOOUTPRS 1730
     -R EXIT AND SUBSONIC*,/,T32,*DIFFUSER ENTRANCE*)                     OUTPRS 1740
```

```
220   FORMAT(*0*,T23,*POINT 6  CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECOUTPRS 1750
     -TOR EXIT AND SUBSONIC*,/,T32,*DIFFUSER ENTRANCE*)                 OUTPRS 1760
221   FORMAT(*0*,                                                       OUTPRS 1770
     -T32,*A6       =*,F13.6,* S-M2/KMOLE*,T66,*G6      =*,E13.6,/,     OUTPRS 1780
     -T32,*MW6      =*,E13.6,* KG/KMOLE*,T66,*M6       =*,F13.6,/,      OUTPRS 1790
     -T32,*P6       =*,E13.6,* PA*,T66,*P60      =*,E13.6,* PA*,/,      OUTPRS 1800
     -T32,*R6       =*,E13.6,* KG/M3*,T66,*R60      =*,E13.6,* KG/M3*,/, OUTPRS 1810
     -T32,*T6       =*,E13.6,* K*,T66,*T60      =*,E13.6,* K*,/,        OUTPRS 1820
     -T32,*W6W1     =*,E13.6,T66,*X6X1      =*,E13.6)                   OUTPRS 1830
222   FORMAT(*0*,T23,*POINT 7  SUBSONIC DIFFUSER EXIT*,//,              OUTPRS 1840
     -T32,*A7       =*,E13.6,* S-M2/KMOLE*,T66,*FTA67    =*,E13.6,/,    OUTPRS 1850
     -T32,*G7       =*,E13.6,T66,*MW7      =*,E13.6,* KG/KMOLE*,/,      OUTPRS 1860
     -T32,*M7       =*,E13.6,T66,*P7       =*,E13.6,* PA*,/,            OUTPRS 1870
     -T32,*P70      =*,E13.6,* PA*,T66,*R7       =*,E13.6,* KG/M3*,/,   OUTPRS 1880
     -T32,*R70      =*,E13.6,* KG/M3*,T66,*T7       =*,E13.6,* K*,/,    OUTPRS 1890
     -T32,*T70      =*,E13.6,* K*,T66,*W7W1     =*,E13.6,/,             OUTPRS 1900
     -T32,*X7X1     =*,E13.6)                                           OUTPRS 1910
      END                                                               OUTPRS 1920
```

```
      SUBROUTINE SDS(G,M1,A2A1,M2,P2P1,P20P10,T2T1,T20T10,RD,           SDS    0100
     -FAIL)                                                             SDS    0110
C                                                                       SDS    0120
C                                                                       SDS    0130
C***********************************************************************SDS    0140
C*                                                                     *SDS    0150
C*                   SUBSONIC DIFFUSER SUBROUTINE (SDS)                *SDS    0160
C*                                                                     *SDS    0170
C***********************************************************************SDS    0180
C                                                                       SDS    0190
C***********************************************************************SDS    0200
C*                                                                     *SDS    0210
C* SUBROUTINE  SDS CALCULATES  THE PRESSURE  RATIO  ACROSS A  CONICAL, *SDS    0220
C* SUBSONIC DIFFUSER WITH AN INCLUDED ANGLE OF 15 DEGREES.  THE STATIC *SDS    0230
C* PRESSURE RATIO IS COMPUTED USING AN EMPERICAL  DIFFUSER EFFICIENCY. *SDS    0240
C* ALL  OTHER  PROPERTIES  ARE  CALCULATED  FROM  THE ISENTROPIC  FLOW *SDS    0250
C* RELATIONS TO BE CONSISTENT WITH THE ENTRANCE AND EXIT MACH NUMBERS. *SDS    0260
C*                                                                     *SDS    0270
C* THE SUBSONIC DIFFUSER EFFICIENCY GIVEN BY:                          *SDS    0280
C*                                                                     *SDS    0290
C*                         EFF=(P2'-P1)/(P2-P1)                        *SDS    0300
C*                                                                     *SDS    0310
C* IS LIMITED TO THE RANGE: 0.2<M1<0.5, 2.34<A2/A1<5.2  AND IS DERIVED *SDS    0320
C* FROM DATA IN THE FOLLOWING REFERENCES:                              *SDS    0330
C*                                                                     *SDS    0340
C*       HENRY,J.R., WOOD,C.C., AND WILBUR,S.W., "SUMMARY OF           *SDS    0350
C*       SUBSONIC-DIFFUSER DATA," NACA RM L56F05 (1956).               *SDS    0360
C*                                                                     *SDS    0370
C*       PATTERSON,G.N., "MODERN DIFFUSER DESIGN," AIRCRAFT            *SDS    0380
C*       ENGINEERING, 9(9):267-273 (1938).                             *SDS    0390
C*                                                                     *SDS    0400
C* THE SUBSONIC DIFFUSER COEFFICIENT IS DEFINED AS:                    *SDS    0410
C*                                                                     *SDS    0420
C*                         RD=(P2'/P1)/(P2/P1)                         *SDS    0430
C*                                                                     *SDS    0440
C* INPUT VARIABLES:                                                    *SDS    0450
C*                                                                     *SDS    0460
C* A2A1    = EXIT-TO-ENTRANCE AREA RATIO                               *SDS    0470
C* G       = GAMMA                                                     *SDS    0480
C* M1      = ENTRANCE MACH NUMBER                                      *SDS    0490
C*                                                                     *SDS    0500
C* OUTPUT VARIABLES:                                                   *SDS    0510
C*                                                                     *SDS    0520
C* FAIL    = ERROR FLAG                                                *SDS    0530
C* M2      = EXIT MACH NUMBER                                          *SDS    0540
C* P2P1    = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO                    *SDS    0550
C* P20P10  = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO                *SDS    0560
C* RD      = SUBSONIC DIFFUSER COEFFICIENT                             *SDS    0570
C* T2T1    = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO                 *SDS    0580
C* T20T10  = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO             *SDS    0590
C*                                                                     *SDS    0600
C***********************************************************************SDS    0610
C                                                                       SDS    0620
C                                                                       SDS    0630
      IMPLICIT REAL(M)                                                  SDS    0640
```

```
      DATA YES/3HYES/,SUB/3HSUB/                                        SDS    0650
C                                                                       SDS    0660
C                                                                       SDS    0670
C***********************************************************************SDS    0680
C*                                                                     *SDS    0690
C*                         GAS DYNAMIC FUNCTIONS                       *SDS    0700
C*                                                                     *SDS    0710
C***********************************************************************SDS    0720
C                                                                       SDS    0730
C                                                                       SDS    0740
      TOTM(GX,MX)=1.0+0.5*(GX-1.0)*MX*MX                                SDS    0750
      POPM(GX,MX)=(1.0+0.5*(GX-1.0)*MX*MX)**(GX/(GX-1.0))               SDS    0760
C                                                                       SDS    0770
C                                                                       SDS    0780
C***********************************************************************SDS    0790
C*                                                                     *SDS    0800
C*                CALCULATIONS FOR CONSTANT-AREA DIFFUSER              *SDS    0810
C*                                                                     *SDS    0820
C***********************************************************************SDS    0830
C                                                                       SDS    0840
C                                                                       SDS    0850
      IF(A2A1.NE.1.0) GO TO 1                                           SDS    0860
      M2=M1                                                             SDS    0870
      P2P1=1.0                                                          SDS    0880
      P20P10=1.0                                                        SDS    0890
      T2T1=1.0                                                          SDS    0900
      T20T10=1.0                                                        SDS    0910
      RD=1.0                                                            SDS    0920
      RETURN                                                            SDS    0930
C                                                                       SDS    0940
C                                                                       SDS    0950
C***********************************************************************SDS    0960
C*                                                                     *SDS    0970
C*                          CALCULATE CONSTANTS                        *SDS    0980
C*                                                                     *SDS    0990
C***********************************************************************SDS    1000
C                                                                       SDS    1010
C                                                                       SDS    1020
1     G2=2.0/(G+1.0)                                                    SDS    1030
      G4=(G+1.0)/(2.0*(G-1.0))                                          SDS    1040
C                                                                       SDS    1050
C                                                                       SDS    1060
C***********************************************************************SDS    1070
C*                                                                     *SDS    1080
C*                           SOLVE A2A2S FOR M2                        *SDS    1090
C*                                                                     *SDS    1100
C***********************************************************************SDS    1110
C                                                                       SDS    1120
C                                                                       SDS    1130
      A1A1S=(1.0/M1)*(G2*TOTM(G,M1))**G4                                SDS    1140
      A2A2S=A2A1*A1A1S                                                  SDS    1150
      CALL MAAS(G,M1,A2A2S,SUB,5.0E-06,M2,FAIL)                         SDS    1160
      IF(FAIL.EQ.YES) RETURN                                            SDS    1170
C                                                                       SDS    1180
C                                                                       SDS    1190
```

```
C***********************************************************************SDS    1200
C*                                                                     *SDS    1210
C*                   CALCULATE THE DIFFUSER EFFICIENCY                 *SDS    1220
C*                                                                     *SDS    1230
C***********************************************************************SDS    1240
C                                                                       SDS    1250
C                                                                       SDS    1260
      EFF=0.002685*A2A1*A2A1*A2A1-0.024461*A2A1*A2A1-0.027229*          SDS    1270
     -A2A1+1.048992                                                     SDS    1280
C                                                                       SDS    1290
C                                                                       SDS    1300
C***********************************************************************SDS    1310
C*                                                                     *SDS    1320
C*               CALCULATE THE IDEAL STATIC PRESSURE RATIO             *SDS    1330
C*                                                                     *SDS    1340
C***********************************************************************SDS    1350
C                                                                       SDS    1360
C                                                                       SDS    1370
      P10P1=P0PM(G,M1)                                                  SDS    1380
      P20P2=P0PM(G,M2)                                                  SDS    1390
      P2P1=P10P1/P20P2                                                  SDS    1400
      RD=EFF+(1.0-EFF)/P2P1                                             SDS    1410
C                                                                       SDS    1420
C                                                                       SDS    1430
C***********************************************************************SDS    1440
C*                                                                     *SDS    1450
C*               CALCULATE THE ACTUAL STATIC PRESSURE RATIO            *SDS    1460
C*                                                                     *SDS    1470
C***********************************************************************SDS    1480
C                                                                       SDS    1490
C                                                                       SDS    1500
      P2P1=RD*P2P1                                                      SDS    1510
      P20P10=P20P2*P2P1/P10P1                                           SDS    1520
      T20T10=1.0                                                        SDS    1530
      T10T1=T0TM(G,M1)                                                  SDS    1540
      T20T2=T0TM(G,M2)                                                  SDS    1550
      T2T1=T10T1*T20T10/T20T2                                           SDS    1560
      END                                                               SDS    1570
```

```
      SUBROUTINE SSEOS(A7A6,GS,GP,LIMIT,MWPMWS,M1,P50P1,P7P1,T50T10,   SSEOS  0100
     -A6A5,ETA67,FAIL,GM,MWMMWP,M5,M6,M7,P5P1,P50P10,P6P5,P60P50,P7P6, SSEOS  0110
     -P70P60,T5T1,T6T5,T60T50,T7T6,T70T60,WPWS)                        SSEOS  0120
C                                                                       SSEOS  0130
C                                                                       SSEOS  0140
C***********************************************************************SSEOS  0150
C*                                                                     *SSEOS  0160
C*     SUPERSONIC-SUPERSONIC EJECTOR OPTIMIZATION SUBROUTINE (SSEOS)   *SSEOS  0170
C*                                                                     *SSEOS  0180
C***********************************************************************SSEOS  0190
C                                                                       SSEOS  0200
C***********************************************************************SSEOS  0210
C*                                                                     *SSEOS  0220
C* SSEOS IS A SUBROUTINE FOR  OPTIMIZING A CONSTANT-AREA,  SUPERSONIC- *SSEOS  0230
C* SUPERSONIC  EJECTOR-SUBSONIC DIFFUSER SUBSYSTEM BY  ONE-DIMENSIONAL *SSEOS  0240
C* ANALYSIS.  THE  OPTIMUM  IS TAKEN TO  BE THAT  CONFIGURATION  WHICH *SSEOS  0250
C* REQUIRES THE MINIMUM DRIVER MASS FLOW FOR A GIVEN DRIVER STAGNATION *SSEOS  0260
C* PRESSURE AND GIVEN COMPRESSION RATIO.                               *SSEOS  0270
C*                                                                     *SSEOS  0280
C* INPUT VARIABLES:                                                    *SSEOS  0290
C*                                                                     *SSEOS  0300
C* A7A6   = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE AREA RATIO              *SSEOS  0310
C* GS     = SECONDARY GAMMA                                            *SSEOS  0320
C* GP     = PRIMARY GAMMA                                              *SSEOS  0330
C* LIMIT  = CONTROL VARIABLE TO SET THE LIMITING CONDITION ON THE      *SSEOS  0340
C*          CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR OPERATION     *SSEOS  0350
C* MWPMWS = PRIMARY-TO-SECONDARY MOLECULAR WEIGHT RATIO                *SSEOS  0360
C* M1     = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE             *SSEOS  0370
C* P50P1  = PRIMARY STAGNATION-TO-SECONDARY STATIC PRESSURE RATIO      *SSEOS  0380
C* P7P1   = SUBSONIC DIFFUSER EXIT-TO-SECONDARY STATIC PRESSURE RATIO  *SSEOS  0390
C* T50T10 = PRIMARY-TO-SECONDARY STAGNATION TEMPERATURE RATIO          *SSEOS  0400
C*                                                                     *SSEOS  0410
C* OUTPUT VARIABLES:                                                   *SSEOS  0420
C*                                                                     *SSEOS  0430
C* A6A5   = MIXING TUBE-TO-PRIMARY NOZZLE EXIT AREA RATIO              *SSEOS  0440
C* ETA67  = SUBSONIC DIFFUSER COEFFICIENT                              *SSEOS  0450
C* FAIL   = ERROR FLAG                                                 *SSEOS  0460
C* GM     = MIXED STREAM GAMMA                                         *SSEOS  0470
C* MWMMWP = MIXED STREAM-TO-PRIMARY MOLECULAR WEIGHT RATIO             *SSEOS  0480
C* M5     = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE               *SSEOS  0490
C* M6     = MIXED STREAM MACH NO. AT THE MIXING TUBE EXIT              *SSEOS  0500
C* M7     = MACH NO. AT THE SUBSONIC DIFFUSER EXIT                     *SSEOS  0510
C* P5P1   = PRIMARY-TO-SECONDARY STATIC PRESSURE RATIO                 *SSEOS  0520
C* P50P10 = PRIMARY-TO-SECONDARY STAGNATION PRESSURE RATIO             *SSEOS  0530
C* P6P5   = MIXED STREAM-TO-PRIMARY STATIC PRESSURE RATIO              *SSEOS  0540
C* P60P50 = MIXED STREAM-TO-PRIMARY STAGNATION PRESSURE RATIO          *SSEOS  0550
C* P7P6   = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STATIC PRESSURE RATIO   *SSEOS  0560
C* P70P60 = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STAGNATION PRESSURE     *SSEOS  0570
C*          RATIO                                                      *SSEOS  0580
C* T5T1   = PRIMARY-TO-SECONDARY STATIC TEMPERATURE RATIO              *SSEOS  0590
C* T6T5   = MIXED STREAM-TO-PRIMARY STATIC TEMPERATURE RATIO           *SSEOS  0600
C* T60T50 = MIXED STREAM-TO-PRIMARY STAGNATION TEMPERATURE RATIO       *SSEOS  0610
C* T7T6   = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STATIC TEMPERATURE      *SSEOS  0620
C*        = RATIO                                                      *SSEOS  0630
C* T70T60 = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STAGNATION TEMPERATURE  *SSEOS  0640
```

```
C*        RATIO                                                        *SSEOS 0650
C* WPWS   = PRIMARY-TO-SECONDARY MASS FLOW RATIO                       *SSEOS 0660
C*                                                                     *SSEOS 0670
C***********************************************************************SSEOS 0680
C                                                                       SSEOS 0690
C                                                                       SSEOS 0700
      IMPLICIT REAL(L,M)                                                SSEOS 0710
      DATA YES/3HYES/                                                   SSEOS 0720
C                                                                       SSEOS 0730
C                                                                       SSEOS 0740
C***********************************************************************SSEOS 0750
C*                                                                     *SSEOS 0760
C*                        GAS DYNAMIC FUNCTIONS                        *SSEOS 0770
C*                                                                     *SSEOS 0780
C***********************************************************************SSEOS 0790
C                                                                       SSEOS 0800
C                                                                       SSEOS 0810
      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M                                     SSEOS 0820
      POPM(G,M)=TOTM(G,M)**(G/(G-1.0))                                  SSEOS 0830
C                                                                       SSEOS 0840
C                                                                       SSEOS 0850
C***********************************************************************SSEOS 0860
C*                                                                     *SSEOS 0870
C*                        CHECK INITIAL DATA                           *SSEOS 0880
C*                                                                     *SSEOS 0890
C***********************************************************************SSEOS 0900
C                                                                       SSEOS 0910
C                                                                       SSEOS 0920
      PDPU=(2.0*GS*M1*M1+1.0-GS)/(GS+1.0)                               SSEOS 0930
      IF(PDPU.GT.P7P1) GO TO 105                                        SSEOS 0940
      MWSMWP=1.0/MWPMWS                                                 SSEOS 0950
      T10T50=1.0/T50T10                                                 SSEOS 0960
C                                                                       SSEOS 0970
C                                                                       SSEOS 0980
C***********************************************************************SSEOS 0990
C*                                                                     *SSEOS 1000
C*                ITERATE A6A5 TO FIND XP50P1=P50P1                    *SSEOS 1010
C*                                                                     *SSEOS 1020
C***********************************************************************SSEOS 1030
C                                                                       SSEOS 1040
C                                                                       SSEOS 1050
      NTYPE2=1                                                          SSEOS 1060
      NIT2=1                                                            SSEOS 1070
      A6A5=20.0                                                         SSEOS 1080
      DO 103 ITER2=1,1000                                               SSEOS 1090
C                                                                       SSEOS 1100
C                                                                       SSEOS 1110
C***********************************************************************SSEOS 1120
C*                                                                     *SSEOS 1130
C*                    ITERATE M5 TO FIND XP7P1=P7P1                    *SSEOS 1140
C*                                                                     *SSEOS 1150
C***********************************************************************SSEOS 1160
C                                                                       SSEOS 1170
C                                                                       SSEOS 1180
      NTYPE3=1                                                          SSEOS 1190
```

```
      NIT3=1                                                            SSEOS  1200
      M5=1.01                                                           SSEOS  1210
      DO 101 ITER3=1,1000                                               SSEOS  1220
C                                                                       SSEOS  1230
C                                                                       SSEOS  1240
C***********************************************************************SSEOS  1250
C*                                                                     *SSEOS  1260
C*            CALCULATIONS FOR SUPERSONIC-SUPERSONIC EJECTOR           *SSEOS  1270
C*                                                                     *SSEOS  1280
C***********************************************************************SSEOS  1290
C                                                                       SSEOS  1300
C                                                                       SSEOS  1310
      A1A5=A6A5-1.0                                                     SSEOS  1320
      CALL SSES(GS,GP,MWSMWP,T10T50,M1,M5,A1A5,LIMIT,WSWP,GM,           SSEOS  1330
     -MWMMWP,T60T50,M6,XP50P1,P6P1,FAIL)                                SSEOS  1340
      IF(FAIL.EQ.YES) GO TO 106                                         SSEOS  1350
C                                                                       SSEOS  1360
C                                                                       SSEOS  1370
C***********************************************************************SSEOS  1380
C*                                                                     *SSEOS  1390
C*                    CALCULATIONS FOR SUBSONIC DIFFUSER               *SSEOS  1400
C*                                                                     *SSEOS  1410
C***********************************************************************SSEOS  1420
C                                                                       SSEOS  1430
C                                                                       SSEOS  1440
      CALL SDS(GM,M6,A7A6,M7,P7P6,P70P60,T7T6,T70T60,ETAS7,FAIL)        SSEOS  1450
      IF(FAIL.EQ.YES) GO TO 107                                         SSEOS  1460
      XP7P1=P7P6*P6P1                                                   SSEOS  1470
C                                                                       SSEOS  1480
C                                                                       SSEOS  1490
C***********************************************************************SSEOS  1500
C*                                                                     *SSEOS  1510
C*                  TEST FOR XP7P1=P7P1 AND INCREMENT M5               *SSEOS  1520
C*                                                                     *SSEOS  1530
C***********************************************************************SSEOS  1540
C                                                                       SSEOS  1550
C                                                                       SSEOS  1560
      CALL ITER(M5,0.5,5.0E-06,+1.0,XP7P1,P7P1,1.0E-01,NIT3,NTYPE3,     SSEOS  1570
     -XNEG3,YNEG3,XPOS3,YPOS3,NSIGN3,NSIGN4)                            SSEOS  1580
      IF(NTYPE3.EQ.3) GO TO 102                                         SSEOS  1590
101   CONTINUE                                                          SSEOS  1600
      GO TO 108                                                         SSEOS  1610
C                                                                       SSEOS  1620
C                                                                       SSEOS  1630
C***********************************************************************SSEOS  1640
C*                                                                     *SSEOS  1650
C*               TEST FOR XP50P1=P50P1 AND INCREMENT A6A5              *SSEOS  1660
C*                                                                     *SSEOS  1670
C***********************************************************************SSEOS  1680
C                                                                       SSEOS  1690
C                                                                       SSEOS  1700
102   CALL ITER(A6A5,0.5,5.0E-06,-1.0,XP50P1,P50P1,1.0E-01,NIT2,NTYPE2, SSEOS  1710
     -XNEG2,YNEG2,XPOS2,YPOS2,NSIGN1,NSIGN2)                            SSEOS  1720
      IF(NTYPE2.EQ.3) GO TO 104                                         SSEOS  1730
103   CONTINUE                                                          SSEOS  1740
```

```
      GO TO 109
104   WPWS=1.0/WSWP
      P5P1=XP50P1/POPM(GP,M5)
      P50P10=XP50P1*POPM(GS,M1)
      T5T1=T50T10*TOTM(GS,M1)/TOTM(GP,M5)
      P6P5=P6P1/P5P1
      P60P50=P6P5*POPM(GM,M6)/POPM(GP,M5)
      T6T5=T60T50*TOTM(GP,M5)/TOTM(GM,M6)
      RETURN
C
C
C***********************************************************************
C*                                                                     *
C*                         FAILURE INDICATORS                          *
C*                                                                     *
C***********************************************************************
C
C
105   WRITE(6,201)
      GO TO 110
106   WRITE(6,202)
      RETURN
107   WRITE(6,203)
      RETURN
108   WRITE(6,204)A6A5,M5,XP7P1,P7P1
      GO TO 110
109   WRITE(6,205)M5,A6A5,XP50P1,P50P1
110   FAIL=YES
C
C
C***********************************************************************
C*                                                                     *
C*                         FORMAT STATEMENTS                           *
C*                                                                     *
C***********************************************************************
C
C
201    FOPMAT(*0*,T2,*WARNING IN SUBROUTINE SSEOS*,/,T2,*THE *,
      -*NORMAL SHOCK STATIC PRESSURE RATIO FOR THE SECONDARY*,/,
      -T2,*STREAM IS GREATER THAN THE REQUESTED COMPRESSION *,
      -*RATIO*,/,T2,*M1       =*,E13.6,T26,*GS       =*,E13.6,/,
      -T2,*PDPU     =*,E13.6,T26,*P7P1     =*,E13.6)
202    FORMAT(*0*,T2,*PROGRAM TERMINATED IN SUBROUTINE SSES*,/,
      -T2,*AS CALLED FROM SUBROUTINE SSEOS*)
203    FORMAT(*0*,T2,*PROGRAM TERMINATED IN SUBROUTINE SDS*,/,
      -T2,*AS CALLED FROM SUBROUTINE SSEOS*)
204    FORMAT(*0*,T2,*CONVERGENCE FAILURE IN SUBROUTINE SSEOS*,/,
      -T2,*FOR M5 SUCH THAT XP7P1=P7P1*,//,
      -T2,*A6A5     =*,E13.6,T26,*M5       =*,E13.6,/,
      -T2,*XP7P1    =*,E13.6,T26,*P7P1     =*,E13.6)
205    FORMAT(*0*,T2,*CONVERGENCE FAILURE IN SUBROUTINE SSEOS*,/,
      -T2,*FOR A6A5 SUCH THAT XP50P1=P50P1*,//,
      -T2,*M5       =*,E13.6,T26,*A6A5     =*,E13.6,/,
      -T2,*XP50P1   =*,E13.6,T26,*P50P1    =*,E13.6)
       END
```

```
      SUBROUTINE SSES(GS,GP,MWSMWP,TSOTPO,MS1,MP1,AS1AP1,LIMIT,         SSES   0100
     -WSWP,GM,MWMMWP,TMOTPO,MM3,PPOPS1,PM3PS1,FAIL)                     SSES   0110
C                                                                       SSES   0120
C                                                                       SSES   0130
C***********************************************************************SSES   0140
C*                                                                     *SSES   0150
C*          SUPERSONIC-SUPERSONIC EJECTOR SUBROUTINE (SSES)            *SSES   0160
C*                                                                     *SSES   0170
C***********************************************************************SSES   0180
C                                                                       SSES   0190
C***********************************************************************SSES   0200
C*                                                                     *SSES   0210
C* SUBROUTINE  SSES CALCULATES  THE  MAXIMUM  COMPRESSION  RATIO FOR A *SSES   0220
C* CONSTANT-AREA,  SUPERSONIC-SUPERSONIC  EJECTOR, BY  ONE-DIMENSIONAL *SSES   0230
C* ANALYSIS.                                                           *SSES   0240
C*                                                                     *SSES   0250
C* INPUT VARIABLES:                                                    *SSES   0260
C*                                                                     *SSES   0270
C* GS     = SECONDARY GAMMA                                            *SSES   0280
C* GP     = PRIMARY GAMMA                                              *SSES   0290
C* MWSMWP = SECONDARY-TO-PRIMARY MOLECULAR WEIGHT RATIO                *SSES   0300
C* TSOTPO = SECONDARY-TO-PRIMARY STAGNATION TEMPERATURE RATIO          *SSES   0310
C* MS1    = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE             *SSES   0320
C* MP1    = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE               *SSES   0330
C* AS1AP1 = SECONDARY-TO-PRIMARY AREA RATIO                            *SSES   0340
C* LIMIT  = CONTROL VARIABLE SUCH THAT:                                *SSES   0350
C*        = "ULP" FOR THE UPPER LIMIT POINT                            *SSES   0360
C*        = "ZSP" FOR THE ZUKOSKI SEPARATION POINT                     *SSES   0370
C*        = "MPP" FOR THE MATCHED PRESSURE POINT                       *SSES   0380
C*                                                                     *SSES   0390
C* OUTPUT VARIABLES:                                                   *SSES   0400
C*                                                                     *SSES   0410
C* WSWP   = SECONDARY-TO-PRIMARY MASS FLOW RATIO                       *SSES   0420
C* GM     = MIXED STREAM GAMMA                                         *SSES   0430
C* MWMMWP = MIXED STREAM-TO-PRIMARY MOLECULAR WEIGHT RATIO             *SSES   0440
C* TMOTPO = MIXED STREAM-TO-PRIMARY STAGNATION TEMPERATURE RATIO       *SSES   0450
C* MM3    = MIXED STREAM MACH NO. AT THE MIXING TUBE EXIT              *SSES   0460
C* PPOPS1 = PRIMARY STAGNATION-TO-SECONDARY STATIC PRESSURE RATIO      *SSES   0470
C* PM3PS1 = STATIC PRESSURE COMPRESSION RATIO                          *SSES   0480
C* FAIL   = ERROR FLAG                                                 *SSES   0490
C*                                                                     *SSES   0500
C***********************************************************************SSES   0510
C                                                                       SSES   0520
C                                                                       SSES   0530
      IMPLICIT REAL(M)                                                  SSES   0540
      REAL LIMIT                                                        SSES   0550
      DATA YES/3HYES/,SUP/3HSUP/,ULP/3HULP/,MPP/3HMPP/                  SSES   0560
C                                                                       SSES   0570
C                                                                       SSES   0580
C***********************************************************************SSES   0590
C*                                                                     *SSES   0600
C*                         SPECIAL FUNCTIONS                           *SSES   0610
C*                                                                     *SSES   0620
C***********************************************************************SSES   0630
C                                                                       SSES   0640
```

```
C
      F(GX,MXX)=1.0+GX*MXX*MXX
      G(GX,MXX)=MXX*SQRT(1.0+0.5*(GX-1.0)*MXX*MXX)
      H(MM,TT,GG)=SQRT(MM*GG/TT)
      PP0(GX,MXX)=(1.0+0.5*(GX-1.0)*MXX*MXX)**(GX/(1.0-GX))
      AAS(GX,MXX)=((2.0*(1.0+0.5*(GX-1.0)*MXX*MXX)/(GX+1.0))**(0.5*(GX+1
     -.0)/(GX-1.0)))/MXX
C
C
C***********************************************************************
C*                                                                     *
C*                        CALCULATE CONSTANTS                          *
C*                                                                     *
C***********************************************************************
C
C
      GS3=GS/(GS-1.0)
      GP3=GP/(GP-1.0)
      GSGP=GS/GP
      MWPMWS=1.0/MWSMWP
      PS1PS0=PP0(GS,MS1)
      PP1PP0=PP0(GP,MP1)
      AS1ASS=AAS(GS,MS1)
      AP1APS=AAS(GP,MP1)
      ASSAS1=1.0/AS1ASS
      FGSMS1=F(GS,MS1)
      FGPMP1=F(GP,MP1)
      GGSMS1=G(GS,MS1)
      GGPMP1=G(GP,MP1)
C
C
C***********************************************************************
C*                                                                     *
C*                        CHECK INITIAL DATA                           *
C*                                                                     *
C***********************************************************************
C
C
      IF(AS1AP1.GT.0.0) GO TO 1
      WRITE(6,6)AS1AP1
      FAIL=YES
      RETURN
1     IF(LIMIT.EQ.ULP) GO TO 2
      IF(LIMIT.EQ.MPP) GO TO 4
      GO TO 3
C
C
C***********************************************************************
C*                                                                     *
C*          CALCULATE PS1PP1 FOR AN ISENTROPIC RECOMPRESSION TO        *
C*          SONIC  CONDITIONS.  MP2  IS OBTAINED  FROM  AP2APS.        *
C*                                                                     *
C***********************************************************************
C
C
```

```
2     AP2APS=AP1APS*(1.0+AS1AP1*(1.0-ASSAS1))                           SSES    1200
      CALL MAAS(GP,MP1,AP2APS,SUP,5.0E-06,MP2,FAIL)                     SSES    1210
      IF(FAIL.EQ.YES) RETURN                                            SSES    1220
      MS2=1.0                                                           SSES    1230
      C1=-FGPMP1+F(GP,MP2)*GGPMP1/G(GP,MP2)                             SSES    1240
      C2=FGSMS1-F(GS,MS2)*GGSMS1/G(GS,MS2)                              SSES    1250
      PS1PP1=C1/(AS1AP1*C2)                                             SSES    1260
      GO TO 5                                                           SSES    1270
C                                                                       SSES    1280
C                                                                       SSES    1290
C***********************************************************************SSES    1300
C*                                                                     *SSES    1310
C*             CALCULATE PS1PP1 AT THE SECONDARY SEPARATION            *SSES    1320
C*             POINT   BASED   ON   A   ZUKOSKI   CRITERIA.            *SSES    1330
C*                                                                     *SSES    1340
C***********************************************************************SSES    1350
C                                                                       SSES    1360
C                                                                       SSES    1370
3     PS2PS1=1.0+0.365*MS1                                              SSES    1380
      PS2PS0=PS1PS0*PS2PS1                                              SSES    1390
      MS2=SQRT(2.0*(PS2PS0**(-1.0/GS3)-1.0)/(GS-1.0))                   SSES    1400
      AS2ASS=AAS(GS,MS2)                                                SSES    1410
      AS2AS1=AS2ASS*ASSAS1                                              SSES    1420
      AP2APS=AP1APS*(1.0+AS1AP1*(1.0-AS2AS1))                           SSES    1430
      CALL MAAS(GP,MP1,AP2APS,SUP,5.0E-06,MP2,FAIL)                     SSES    1440
      IF(FAIL.EQ.YES) RETURN                                            SSES    1450
      C1=-FGPMP1+F(GP,MP2)*GGPMP1/G(GP,MP2)                             SSES    1460
      C2=FGSMS1-F(GS,MS2)*GGSMS1/G(GS,MS2)                              SSES    1470
      PS1PP1=C1/(AS1AP1*C2)                                             SSES    1480
      GO TO 5                                                           SSES    1490
C                                                                       SSES    1500
C                                                                       SSES    1510
C***********************************************************************SSES    1520
C*                                                                     *SSES    1530
C*          CALCULATE PS1PP1 AT THE MATCHED PRESSURE POINT             *SSES    1540
C*                                                                     *SSES    1550
C***********************************************************************SSES    1560
C                                                                       SSES    1570
C                                                                       SSES    1580
4     PS1PP1=1.0                                                        SSES    1590
C                                                                       SSES    1600
C                                                                       SSES    1610
C***********************************************************************SSES    1620
C*                                                                     *SSES    1630
C*                OVERALL CONTROL VOLUME CALCULATIONS                  *SSES    1640
C*                                                                     *SSES    1650
C***********************************************************************SSES    1660
C                                                                       SSES    1670
C                                                                       SSES    1680
5     WSWP=PS1PP1*AS1AP1*H(MWSMWP,TSOTPO,GSGP)*GGSMS1/GGPMP1            SSES    1690
      C1=WSWP*MWPMWS*GS3+GP3                                            SSES    1700
      C2=WSWP*MWPMWS*(GS3-1.0)+(GP3-1.0)                                SSES    1710
      GM=C1/C2                                                          SSES    1720
      GMGP=GM/GP                                                        SSES    1730
      MWNMWP=(WSWP+1.0)/(WSWP*MWPMWS+1.0)                               SSES    1740
```

```
      C1=TSOTP0*WSWP*MWPMWS*GS3*GP3
      C2=WSWP*MWPMWS*GS3*GP3
      TMOTP0=C1/C2
      FFX=H(MWMMWP,TMOTP0,GMGP)*(PS1PP1*AS1AP1*FGSMS1+FGPMP1)/(
     -(1.0+WSWP)*GGPMP1)
      C1=0.5*(GM-1.0)*FFX*FFX-GM*GM
      C2=FFX*FFX-2.0*GM
      C3=(-C2+SQRT(C2*C2+4.0*C1))/(2.0*C1)
      C4=(-C2-SQRT(C2*C2+4.0*C1))/(2.0*C1)
      MM3=SQRT(AMIN1(C3,C4))
      PM3PP1=(PS1PP1*AS1AP1*FGSMS1+FGPMP1)/((1.0+AS1AP1)*F(GM,MM3))
      PM3PS1=PM3PP1/PS1PP1
      PS1PP0=PS1PP1*PP1PP0
      PP0PS1=1.0/PS1PP0
C
C
C***********************************************************************
C*                                                                     *
C*                          FORMAT STATEMENTS                          *
C*                                                                     *
C***********************************************************************
C
C
6     FORMAT(*0*,T2,*IMPOSSIBLE VALUE...AS1AP1 =*,E13.6)
      END
```

Appendix E. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)–OVERLAY SCS

```
      OVERLAY(SCS,4,0)
      PROGRAM SCS
C
C
C************************************************************************
C*                                                                      *
C*              SYSTEM CALCULATION OVERLAY (SCS)                        *
C*                                                                      *
C************************************************************************
C
C************************************************************************
C*                                                                      *
C*  SUBROUTINE SCS CONTROLS THE SYSTEM CALCULATIONS FOR PROGRAM CLAP.   *
C*                                                                      *
C* INPUT VARIABLES:                                                     *
C*                                                                      *
C* AEPNE  = TOTAL AREA OF THE EJECTOR PRIMARY NOZZLE EXITS PER KMOLE/S *
C*          OF LASER PRIMARY FLOW [S-M2/KMOLE]                          *
C* AESHRD = TOTAL AREA OF THE EJECTOR, CONSTANT-AREA, MIXING SHROUDS    *
C*          PER KMOLE/S OF LASER PRIMARY FLOW [S-M2/KMOLE]              *
C* BRFRAC = BANK RELIEF FRACTION                                        *
C* CANGLE = LASER CAVITY HALF-ANGLE [RAD]                               *
C* DFORHF = CONTROL VARIABLE DESIGNATING DF OR HF LASER CHEMISTRY       *
C* EJECT  = CONTROL VARIABLE DESIGNATING THE PRESSURE RECOVERY SYSTEM   *
C* EREACT = CONTROL VARIABLE DESIGNATING THE EJECTOR PRIMARY REACTANT   *
C* FDAA   = FREE FLUORINE FLUX [KMOLE/S-M2]                             *
C* GEP    = GAMMA, SPECIFIC HEAT RATIO, FOR THE EJECTOR PRIMARY         *
C*          REACTANT                                                    *
C* HBASE  = HEIGHT OF A NOZZLE BASE [M]                                 *
C* HNB    = HEIGHT OF A NOZZLE BANK [M]                                 *
C* K      = STORAGE MODE CONTROL ARRAY                                  *
C* LCAV   = LENGTH OF A LASER CAVITY [M]                                *
C* MEPNE  = MACH NO. AT THE EJECTOR PRIMARY NOZZLE EXIT                 *
C* NBANK  = NUMBER OF LASER BANKS                                       *
C* NEJECT = NUMBER OF EJECTORS PER LASER BANK                           *
C* N1     = NUMBER OF CARBON ATOMS IN PRIMARY REACTANT 1                *
C* N2     = NUMBER OF HYDROGEN (DEUTERIUM) ATOMS IN PRIMARY REACTANT 1  *
C* N3     = NUMBER OF NITROGEN ATOMS IN PRIMARY REACTANT 4              *
C* N4     = NUMBER OF FLUORINE ATOMS IN PRIMARY REACTANT 4              *
C* POEP   = EJECTOR PRIMARY STAGNATION PRESSURE [PA]                    *
C* POLP   = LASER PRIMARY STAGNATION PRESSURE [PA]                      *
C* POLS   = LASER SECONDARY STAGNATION PRESSURE [PA]                    *
C* Q      = HEAT RELEASED PER KMOLE OF PRIMARY FLOW BY THE CHEMICAL     *
C*          REACTION OF FLUORINE IN THE LASER CAVITY [J/KMOLE]          *
C* RTIME  = RUN TIME [S]                                                *
C* SCSS2  = CONTROL VARIABLE DESIGNATING WHETHER OR NOT SYSTEM          *
C*          CALCULATIONS ARE TO BE PERFORMED                            *
C* STMODE = REACTANT STORAGE MODE DESCRIPTOR ARRAY                      *
C* WEPWLT = EJECTOR PRIMARY-TO-TOTAL LASER MASS FLOW RATIO              *
C* WFPP3  = MASS FRACTION OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)    *
C* WFPR1  = MASS FRACTION OF LASER PRIMARY REACTANT 1                   *
C* WFPR2  = MASS FRACTION OF LASER PRIMARY REACTANT 2                   *
C* WFPR3  = MASS FRACTION OF LASER PRIMARY REACTANT 3                   *
C* WFPR4  = MASS FRACTION OF LASER PRIMARY REACTANT 4                   *
C* WFSR1  = MASS FRACTION OF LASER SECONDARY REACTANT 1                 *
```

```
C* WFSR2  = MASS FRACTION OF LASER SECONDARY REACTANT 2                *SCS    0650
C* WFSR3  = MASS FRACTION OF LASER SECONDARY REACTANT 3                *SCS    0660
C* WLSWLP = LASER SECONDARY-TO-PRIMARY REACTANT MASS FLOW RATIO        *SCS    0670
C* WPGWLP = MIRROR PURGE-TO-LASER PRIMARY REACTANT MASS FLOW RATIO     *SCS    0680
C* WPP3   = MASS FLOW RATE OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)  *SCS    0690
C*          (KG/S)                                                     *SCS    0700
C* XFPP3  = MOLE FRACTION OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)   *SCS    0710
C*                                                                     *SCS    0720
C* OUTPUT VARIABLES:                                                   *SCS    0730
C*                                                                     *SCS    0740
C* FAIL   = ERROR FLAG                                                 *SCS    0750
C* HBXDEV = HEIGHT OF THE BOX DEVICE (M)                               *SCS    0760
C* LBXDEV = LENGTH OF THE BOX DEVICE (M)                               *SCS    0770
C* LLDS   = LENGTH OF THE LASER DEVICE SECTION (M)                     *SCS    0780
C* LPRS   = LENGTH OF THE PRESSURE RECOVERY SYSTEM (M)                  *SCS    0790
C* MAW    = TOTAL MASS OF THE AERO-WINDOWS (KG)                        *SCS    0800
C* MBASE  = TOTAL MASS OF THE LASER NOZZLE BASES (KG)                  *SCS    0810
C* MCAV   = TOTAL MASS OF THE LASER CAVITIES (KG)                      *SCS    0820
C* MCB    = TOTAL MASS OF THE COMBUSTOR BODIES (KG)                    *SCS    0830
C* MCS    = MASS OF THE COOLING SYSTEM (KG)                            *SCS    0840
C* MDS    = MASS OF THE DEVICE SUPPORT (KG)                            *SCS    0850
C* MEJECT = TOTAL MASS OF THE EJECTORS (KG)                            *SCS    0860
C* MELINE = MASS OF THE EJECTOR REACTANT FEED LINES (KG)               *SCS    0870
C* MERREG = MASS OF THE EJECTOR PRIMARY REACTANT REGULATOR (KG)        *SCS    0880
C* MERT   = MASS OF THE EJECTOR PRIMARY REACTANT TANKAGE AND FLUID     *SCS    0890
C*          (KG)                                                       *SCS    0900
C* MINJ   = TOTAL MASS OF THE INJECTORS (KG)                           *SCS    0910
C* MLDHDW = MASS OF THE LASER DEVICE HARDWARE (KG)                     *SCS    0920
C* MLDS   = MASS OF THE LASER DEVICE SYSTEM (KG)                       *SCS    0930
C* MLLINE = MASS OF THE LASER REACTANT FEED LINES (KG)                 *SCS    0940
C* MLRREG = MASS OF THE LASER REACTANT REGULATOR (KG)                  *SCS    0950
C* MLRT   = MASS OF THE LASER REACTANT TANKAGE AND FLUID (KG)          *SCS    0960
C* MMISC  = MASS OF MISCELLANEOUS ITEMS (KG)                           *SCS    0970
C* MOPT   = TOTAL MASS OF THE LASER OPTICS (KG)                        *SCS    0980
C* MPRHDW = MASS OF THE PRESSURE RECOVERY HARDWARE (KG)                *SCS    0990
C* MPRS   = MASS OF THE PRESSURE RECOVERY SYSTEM (KG)                  *SCS    1000
C* MSUBD  = TOTAL MASS OF THE SUBSONIC DIFFUSERS (KG)                  *SCS    1010
C* MSUPD  = TOTAL MASS OF THE SUPERSONIC DIFFUSERS (KG)                *SCS    1020
C* MTOTAL = TOTAL SYSTEM MASS (KG)                                     *SCS    1030
C* VAW    = TOTAL VOLUME OF THE AERO-WINDOWS (M3)                      *SCS    1040
C* VBXDEV = VOLUME OF THE BOX DEVICE (M3)                              *SCS    1050
C* VCAV   = TOTAL VOLUME OF THE LASER CAVITIES (M3)                    *SCS    1060
C* VCOMB  = TOTAL VOLUME OF THE LASER COMBUSTORS (M3)                   *SCS    1070
C* VCS    = VOLUME OF THE COOLING SYSTEM (M3)                           *SCS    1080
C* VEJECT = TOTAL VOLUME OF THE EJECTORS (M3)                          *SCS    1090
C* VERT   = VOLUME OF THE EJECTOR PRIMARY REATANT TANKAGE (M3)         *SCS    1100
C* VLDHDW = VOLUME OF THE LASER DEVICE HARDWARE (M3)                   *SCS    1110
C* VLDS   = VOLUME OF THE LASER DEVICE SYSTEM (M3)                     *SCS    1120
C* VLRT   = VOLUME OF THE LASER REACTANT TANKAGE (M3)                  *SCS    1130
C* VOPT   = TOTAL VOLUME OF THE LASER OPTICS (M3)                      *SCS    1140
C* VPRHDW = VOLUME OF THE PRESSURE RECOVERY HARDWARE (M3)              *SCS    1150
C* VPRS   = VOLUME OF THE PRESSURE RECOVERY SYSTEM (M3)                *SCS    1160
C* VSUBD  = TOTAL VOLUME OF THE SUBSONIC DIFFUSERS (M3)                *SCS    1170
C* VSUPD  = TOTAL VOLUME OF THE SUPERSONIC DIFFUSERS (M3)              *SCS    1180
C* VSYSTM = TOTAL VOLUME CONTAINING THE SYSTEM (M3)                    *SCS    1190
```

```
C* VTOTAL = TOTAL VOLUME OCCUPIED BY THE SYSTEM (M3)                    *SCS     1200
C* WBASE  = WIDTH OF A NOZZLE BASE (M3)                                 *SCS     1210
C* WBXDEV = WIDTH OF THE BOX DEVICE (M3)                                *SCS     1220
C* XLP    = LASER PRIMARY PRODUCT MOLAR FLOW RATE (KMOLE/S)             *SCS     1230
C*                                                                      *SCS     1240
C***********************************************************************SCS     1250
C                                                                        SCS     1260
C***********************************************************************SCS     1270
C*                                                                      *SCS     1280
C*                           NOTATION SCHEME                            *SCS     1290
C*                                                                      *SCS     1300
C*   THE STORAGE MODE DESCRIPTOR ARRAY, STMODE(I,J), STORES  DATA BY    *SCS     1310
C*   DESCRIPTOR (ROW) AS FOLLOWS:                                       *SCS     1320
C*                                                                      *SCS     1330
C*       I DESCRIPTOR                      I DESCRIPTOR                 *SCS     1340
C*       1 REACTANT                        6 STORAGE TIME (DAYS)        *SCS     1350
C*       2 PHASE                           7 STORAGE PRESSURE (PA)      *SCS     1360
C*       3 CONTAINER                       8 STORAGE PRESSURE (PSI)     *SCS     1370
C*       4 STORAGE TEMPERATURE (K)         9 REACTANT FEED SYSTEM       *SCS     1380
C*       5 STORAGE TIME (S)               10 MATERIAL                   *SCS     1390
C*                                                                      *SCS     1400
C*   AND BY FLUID (COLUMN) AS FOLLOWS:                                  *SCS     1410
C*                                                                      *SCS     1420
C*       J                                 J                            *SCS     1430
C*       1 DESCRIPTOR                      6 LASER REACTANT 5           *SCS     1440
C*       2 LASER REACTANT 1                7 AERO-WINDOW FLUID          *SCS     1450
C*       3 LASER REACTANT 2                8 COOLING SYSTEM FLUID       *SCS     1460
C*       4 LASER REACTANT 3                9 EJECTOR REACTANT 1         *SCS     1470
C*       5 LASER REACTANT 4               10 EJECTOR REACTANT 2         *SCS     1480
C*                                                                      *SCS     1490
C***********************************************************************SCS     1500
C                                                                        SCS     1510
C                                                                        SCS     1520
      IMPLICIT REAL(L,M)                                                 SCS     1530
C                                                                        SCS     1540
      REAL NO                                                            SCS     1550
C                                                                        SCS     1560
      COMMON/CCS3/DFORHF                                                 SCS     1570
C                                                                        SCS     1580
      COMMON/CCS4/FDAA                                                   SCS     1590
C                                                                        SCS     1600
      COMMON/CCS5/N1,N2,N3,N4                                            SCS     1610
C                                                                        SCS     1620
      COMMON/CCS7/Q                                                      SCS     1630
C                                                                        SCS     1640
      COMMON/CCS9/WFPP3,WFPR1,WFPR4,WFSR1                                SCS     1650
C                                                                        SCS     1660
      COMMON/CCS10/WFPR2,WFPR3,WFSR2,WFSR3                               SCS     1670
C                                                                        SCS     1680
      COMMON/CCS11/WPGWLP                                                SCS     1690
C                                                                        SCS     1700
      COMMON/CCS15/XFPP3                                                 SCS     1710
C                                                                        SCS     1720
      COMMON/LDS5/BRFRAC,CANGLE,HBASE,HNB,LCAV                           SCS     1730
C                                                                        SCS     1740
```

```
      COMMON/LDS6/POLP,POLS,WLSWLP                                      SCS    1750
C                                                                       SCS    1760
      COMMON/MAIN1/FAIL                                                 SCS    1770
C                                                                       SCS    1780
      COMMON/PRS4/AEPNE,AESHPD,MEPNE,WEPWLT                             SCS    1790
C                                                                       SCS    1800
      COMMON/PRS5/EJECT                                                 SCS    1810
C                                                                       SCS    1820
      COMMON/PRS6/GEP,POEP                                              SCS    1830
C                                                                       SCS    1840
      COMMON/SCS1/SCSS2                                                 SCS    1850
C                                                                       SCS    1860
      COMMON/SCS2/EREACT,NRANK,NEJECT,RTIME,WPP3                        SCS    1870
C                                                                       SCS    1880
C                                                                       SCS    1890
      COMMON/SCS3/HBXDEV,LBXDEV,LLDS,LPRS,MAW,MBASE,MCAV,MCB,MCS,MDS,   SCS    1900
     -MEJECT,MELINE,MERREG,MERT,MINJ,MLDHDW,MLDS,MLLINE,MLRREG,MLRT,    SCS    1910
     -MMISC,MOPT,MPRHDW,MPRS,MSUBD,MSUPD,MTOTAL,VAW,VBXDEV,VCAV,VCOMB,  SCS    1920
     -VCS,VEJECT,VERT,VLDHDW,VLDS,VLRT,VOPT,VPRHDW,VPRS,VSUBD,VSUPD,    SCS    1930
     -VSYSTM,VTOTAL,WBASE,WBXDEV,XLP                                    SCS    1940
C                                                                       SCS    1950
      COMMON/SCS4/K(10)                                                 SCS    1960
C                                                                       SCS    1970
      COMMON/SCS5/STMODE(10,10)                                         SCS    1980
C                                                                       SCS    1990
      DATA SDANGL/0.122173/,TRANG1/0.523599/,TRANG2/0.523599/           SCS    2000
C                                                                       SCS    2010
      DATA CAE/3HCAE/,DIF/3HDIF/,HF/2HHF/,NO/2HNO/,SSE/3HSSE/,YES/3HYES/SCS    2020
C                                                                       SCS    2030
C                                                                       SCS    2040
C***********************************************************************SCS    2050
C*                                                                     *SCS    2060
C*                          FUNCTION STATEMENTS                        *SCS    2070
C*                                                                     *SCS    2080
C***********************************************************************SCS    2090
C                                                                       SCS    2100
C                                                                       SCS    2110
      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M                                     SCS    2120
      AASM(G,M)=((2.0*TOTM(G,M)/(G+1.0))**(0.5*(G+1.0)/(G-1.0)))/M      SCS    2130
C                                                                       SCS    2140
C                                                                       SCS    2150
C***********************************************************************SCS    2160
C*                                                                     *SCS    2170
C*                            READ INPUT DATA                          *SCS    2180
C*                                                                     *SCS    2190
C***********************************************************************SCS    2200
C                                                                       SCS    2210
C                                                                       SCS    2220
      CALL INSCS                                                        SCS    2230
      IF(FAIL.EQ.YES) GO TO 120                                         SCS    2240
      IF(SCSS2.EQ.NO) GO TO 202                                         SCS    2250
C                                                                       SCS    2260
C                                                                       SCS    2270
C***********************************************************************SCS    2280
C*                                                                     *SCS    2290
```

```
C*           INITIALIZE THE STORAGE MODE DESCRIPTOR                    *SCS     2300
C*           ARRAY  AND TANK VOLUME/MASS  VARIABLES                    *SCS     2310
C*                                                                     *SCS     2320
C***********************************************************************SCS     2330
C                                                                       SCS     2340
C                                                                       SCS     2350
      DO 101 I=1,10                                                     SCS     2360
      DO 101 J=2,10                                                     SCS     2370
101   STMODE(I,J)=10H                                                   SCS     2380
      MERT=0.0                                                          SCS     2390
      MLRT=0.0                                                          SCS     2400
      VERT=0.0                                                          SCS     2410
      VLRT=0.0                                                          SCS     2420
C                                                                       SCS     2430
C                                                                       SCS     2440
C***********************************************************************SCS     2450
C*                                                                     *SCS     2460
C*                     SYSTEM SCALE-UP CALCULATIONS                    *SCS     2470
C*                                                                     *SCS     2480
C***********************************************************************SCS     2490
C                                                                       SCS     2500
C                                                                       SCS     2510
      XLP=WPP3/(XFPP3*18.9984)                                          SCS     2520
C                                                                       SCS     2530
C                                                                       SCS     2540
C***********************************************************************SCS     2550
C*                                                                     *SCS     2560
C*  CALCULATE THE LASER PRIMARY & SECONDARY REACTANT TANK VOLUME/MASS  *SCS     2570
C*                                                                     *SCS     2580
C***********************************************************************SCS     2590
C                                                                       SCS     2600
C                                                                       SCS     2610
      WLP=WPP3/WFPP3                                                    SCS     2620
      MLPR=WLP*RTIME                                                    SCS     2630
      WLS=WLSWLP*WLP                                                    SCS     2640
      MLSR=WLS*RTIME                                                    SCS     2650
C                                                                       SCS     2660
      IF(DFORHF.NE.HF) GO TO 102                                        SCS     2670
      CALL VMD2(2,WFPR1*MLPR,POLP,MLRT,VLRT)                            SCS     2680
      GO TO 105                                                         SCS     2690
102   IF(N1.EQ.2.AND.N2.EQ.4) GO TO 103                                 SCS     2700
      IF(N1.EQ.0.AND.N2.EQ.2) GO TO 104                                 SCS     2710
103   CALL VMC2H6(2,WFPR1*MLPR,POLP,MLRT,VLRT)                          SCS     2720
      GO TO 105                                                         SCS     2730
104   CALL VMH2(2,WFPR1*MLPR,POLP,MLRT,VLRT)                            SCS     2740
105   NTANK=1                                                           SCS     2750
C                                                                       SCS     2760
      MHE=WFPR2*MLPR+WFSR2*MLSR                                         SCS     2770
      IF(K(5).LT.3.AND.WFSR2.EQ.0.0) GO TO 106                          SCS     2780
      IF(MHE.EQ.0.0) GO TO 106                                          SCS     2790
      IF(WFPR2.NE.0.0.AND.WFSR2.NE.0.0) PO=AMAX1(POLP,POLS)             SCS     2800
      IF(WFPR2.NE.0.0.AND.WFSR2.EQ.0.0) PO=POLP                         SCS     2810
      IF(WFPR2.EQ.0.0.AND.WFSR2.NE.0.0) PO=POLS                         SCS     2820
      CALL VMHE(3,MHE,PO,MLRT,VLRT)                                     SCS     2830
      NTANK=NTANK+1                                                     SCS     2840
```

```
      MHE=0.0                                                           SCS     2850
C                                                                       SCS     2860
106   IF(N3.EQ.0.0.AND.N4.EQ.2) GO TO 107                               SCS     2870
      CALL VMNF3(5,MHE,WFPR4*MLPR,POLP,MLRT,VLRT)                       SCS     2880
      GO TO 108                                                         SCS     2890
107   CALL VMF2(5,WFPR4*MLPP,MHE,POLP,MLRT,VLRT)                        SCS     2900
108   NTANK=NTANK+1                                                     SCS     2910
C                                                                       SCS     2920
      IF(WFPR3.EQ.0.0.AND.WFSR3.EQ.0.0) GO TO 109                       SCS     2930
      IF(WFPR3.NE.0.0.AND.WFSR3.NE.0.0) PO=AMAX1(POLP,POLS)             SCS     2940
      IF(WFPP3.NE.0.0.AND.WFSR3.EQ.0.0) PO=POLP                         SCS     2950
      IF(WFPR3.EQ.0.0.AND.WFSR3.NE.0.0) PO=POLS                         SCS     2960
      CALL VMN2(4,WFPR3*MLPR+WFSR3*MLSR,PO,MLRT,VLRT)                   SCS     2970
      NTANK=NTANK+1                                                     SCS     2980
C                                                                       SCS     2990
109   IF(DFORHF.EQ.HF) CALL VMH2(6,WFSR1*MLSR,POLS,MLRT,VLRT)           SCS     3000
      IF(DFORHF.NE.HF) CALL VMD2(6,WFSR1*MLSR,POLS,MLRT,VLRT)           SCS     3010
      NTANK=NTANK+1                                                     SCS     3020
C                                                                       SCS     3030
      MLRREG=NTANK*(WLP+WLS)                                            SCS     3040
C                                                                       SCS     3050
C                                                                       SCS     3060
C***********************************************************************SCS     3070
C*                                                                     *SCS     3080
C*                CALCULATE THE LASER DEVICE VOLUME/MASS               *SCS     3090
C*                                                                     *SCS     3100
C***********************************************************************SCS     3110
C                                                                       SCS     3120
C                                                                       SCS     3130
      ANR=XLP*XFPR3/(FDAA*NBANK)                                        SCS     3140
      WNR=ANR/HNB                                                       SCS     3150
      ABASE=ANR/NRFRAC                                                  SCS     3160
      WBASE=ABASE/HBASE                                                 SCS     3170
      DA=HBASE+2.0*LCAV*TAN(CANGLE)                                     SCS     3180
      NMAX=WBASE/DA                                                     SCS     3190
C                                                                       SCS     3200
      LINJ=1.05587E-08*POLP*HBASE+1.143E-02                             SCS     3210
      MINJ=7.94690E+03*ABASE*LINJ*NBANK                                 SCS     3220
      WCB=WBASE/NMAX                                                    SCS     3230
      MCB=1.82687E+04*(1.10519E-09*POLP*((WCB+5.08E-04)*WCB+(HBASE+     SCS     3240
     -5.08E-04)*HBASE)+7.61289E-05*(WCB+HBASE+1.016E-02))*NMAX*NBANK    SCS     3250
      MBASE=150.808*ABASE*NBANK                                         SCS     3260
      LCOMB=AMAX1(2.0*HBASE,LINJ+0.101600)                              SCS     3270
      VCOMB=ABASE*LCOMB*NBANK                                           SCS     3280
C                                                                       SCS     3290
      ASCAV=2.0*LCAV*WBASE/COS(CANGLE)                                  SCS     3300
      TAU=AMAX1(1.27000E-03,4.77465E-03*DA)                             SCS     3310
      MCAV=7.91645E+03*TAU*ASCAV*NBANK                                  SCS     3320
      VCAV=WBASE*LCAV*(HBASE+DA)*NBANK/2.0                              SCS     3330
C                                                                       SCS     3340
      DMIR=SQRT(LCAV*LCAV+DA*DA)                                        SCS     3350
      B=DMIR 2.54000E-02                                                SCS     3360
      MMIR=1032.28*DMIR**2.5                                            SCS     3370
      MOPT=(3.0*MMIR+276.530*B*(WBASE+B+0.609600)*(0.125*WBASE+B+       SCS     3380
     -7.62000E-02)+36.2874)*NBANK                                       SCS     3390
```

```
      VOPT=(0.785398*B*B*(WBASE+0.609600)+7.29659*B+2.78000E-03-        SCS    3400
     -LCAV*WBASE*(DA-HBASE)/2.0)*NBANK                                  SCS    3410
C                                                                       SCS    3420
      MDS=0.1*(MINJ+MCR+MBASE+MCAV+MOPT)                                SCS    3430
C                                                                       SCS    3440
C                                                                       SCS    3450
C***********************************************************************SCS    3460
C*                                                                     *SCS    3470
C*                CALCULATE THE AERO-WINDOW VOLUME/MASS                *SCS    3480
C*                                                                     *SCS    3490
C***********************************************************************SCS    3500
C                                                                       SCS    3510
C                                                                       SCS    3520
      WPURGE=WPGWLP*WLP                                                 SCS    3530
      WAW=3.32520*HBASE*NBANK                                           SCS    3540
      WAWL=1.57480E-02*HBASE*NBANK                                      SCS    3550
      MAWF=(WAW+WPURGE)*RTIME                                           SCS    3560
      CALL VMAW(7,MAWF,RTIME,MLRT,VLRT)                                 SCS    3570
      NTANK=NTANK+1                                                     SCS    3580
      MAW=413.591*HBASE*NBANK                                           SCS    3590
      VAW=0.309974*HBASE*NBANK                                          SCS    3600
C                                                                       SCS    3610
C                                                                       SCS    3620
C***********************************************************************SCS    3630
C*                                                                     *SCS    3640
C*               CALCULATE THE COOLING SYSTEM VOLUME/MASS              *SCS    3650
C*                                                                     *SCS    3660
C***********************************************************************SCS    3670
C                                                                       SCS    3680
C                                                                       SCS    3690
      WCS=3.98076E-07*Q*XLP                                             SCS    3700
      IF(K(10).EQ.5) WCS=3.0*WCS                                        SCS    3710
      MCSF=WCS*RTIME                                                    SCS    3720
      CALL VMCS(8,MCSF,RTIME,MCS,VCS)                                   SCS    3730
      NTANK=NTANK+1                                                     SCS    3740
C                                                                       SCS    3750
      LLINE=NTANK*(1.73205*(VLRT+VCS)**(1.0/3.0)+NBANK*                 SCS    3760
     -SQRT(HBASE*HBASE+WBASE*WBASE+(LCOMB+LCAV)**2))                    SCS    3770
      MLLINE=0.226239*LLINE                                             SCS    3780
C                                                                       SCS    3790
C                                                                       SCS    3800
C***********************************************************************SCS    3810
C*                                                                     *SCS    3820
C*         CALCULATE THE SUPERSONIC/SUBSONIC DIFFUSER VOLUME/MASS      *SCS    3830
C*                                                                     *SCS    3840
C***********************************************************************SCS    3850
C                                                                       SCS    3860
C                                                                       SCS    3870
      IF(EJECT.EQ.NO) GO TO 115                                         SCS    3880
      IF(EJECT.EQ.SSE) GO TO 110                                        SCS    3890
      LSUPD=9.0*DA                                                      SCS    3900
      ASSUPD=LSUPD*(2.0*WBASE+(NMAX+1)*DA)                              SCS    3910
      MSUPD=7.91645E+03*TAU*ASSUPD*NBANK                                SCS    3920
      VSUPD=DA*WBASE*LSUPD*NBANK                                        SCS    3930
C                                                                       SCS    3940
```

```
      LSURD=3.0*DA                                                      SCS     3950
      DB=DA+2.0*LSURD*TAN(SDANGL)                                       SCS     3960
      ASSURD=LSURD*(2.0*WBASE/COS(SDANGL)+(NMAX+1)*(DA+DB)/2.0)         SCS     3970
      TAU=AMAX1(1.27000E-03,4.77465E-03*DB)                             SCS     3980
      MSURD=7.91645E+03*TAU*ASSURD*NBANK                                SCS     3990
      VSURD=WBASE*LSURD*(DA+DB)*NBANK/2.0                               SCS     4000
C                                                                       SCS     4010
C                                                                       SCS     4020
C***********************************************************************SCS     4030
C*                                                                     *SCS     4040
C*       CALCULATE THE EJECTOR PRIMARY REACTANT TANK VOLUME/MASS       *SCS     4050
C*                                                                     *SCS     4060
C***********************************************************************SCS     4070
C                                                                       SCS     4080
C                                                                       SCS     4090
110   IF(EJECT.EQ.DIF) GO TO 115                                        SCS     4100
      WLT=WLP+WLS+WAWL+WPURGE                                           SCS     4110
      WEP=WEPWLT*WLT                                                    SCS     4120
      MEPR=WEP*RTIME                                                    SCS     4130
      IF(EREACT.EQ.10HN2H4      ) GO TO 111                             SCS     4140
      IF(EREACT.EQ.10HIRFNA/MMH ) GO TO 112                             SCS     4150
111   CALL VMN2H4(9,MEPR,P0EP,RTIME,MERT,VERT)                          SCS     4160
      NTANK=1                                                           SCS     4170
      MERREG=1.5*WEP                                                    SCS     4180
      GO TO 113                                                         SCS     4190
112   CALL VMMMH(9,0.65*MEPR,P0EP,RTIME,MERT,VERT)                      SCS     4200
      CALL VMIRFNA(10,0.35*MEPR,P0EP,RTIME,MERT,VERT)                   SCS     4210
      NTANK=2                                                           SCS     4220
      MERREG=2.5*WEP                                                    SCS     4230
C                                                                       SCS     4240
C                                                                       SCS     4250
C***********************************************************************SCS     4260
C*                                                                     *SCS     4270
C*       CALCULATE THE SUBSONIC/SUPERSONIC EJECTOR VOLUME/MASS         *SCS     4280
C*                                                                     *SCS     4290
C***********************************************************************SCS     4300
C                                                                       SCS     4310
C                                                                       SCS     4320
113   IF(EJECT.EQ.SSE) GO TO 114                                        SCS     4330
      NMAX=WBASE/DB                                                     SCS     4340
      IF(NEJECT.EQ.0.OR.NEJECT.GT.NMAX) NEJECT=NMAX                     SCS     4350
      WTR=WBASE/NEJECT                                                  SCS     4360
      DC=SQRT(WTR*DB)                                                   SCS     4370
      LTR1=(DC-DB)/(2.0*TAN(TRANG1))                                    SCS     4380
      THETA=ATAN((WTR-DC)/(2.0*LTR1))                                   SCS     4390
      DD=1.12838*DC                                                     SCS     4400
      LTR2=(DD-DC)/(2.0*TAN(TRANG2))                                    SCS     4410
      ASTR=LTR1*((WTR+DC)/COS(TRANG1)+(DB+DC)/COS(THETA))+LTR2*(2.0*DC+ SCS     4420
     -1.57080*DD)                                                       SCS     4430
      TAU=AMAX1(1.27000E-03,3.75000E-03*DD)                             SCS     4440
      MTR=7.91645E+03*TAU*ASTR*NEJECT*NBANK                             SCS     4450
      VTR=DC*DC*(LTR1+LTR2)*NEJECT*NBANK                                SCS     4460
C                                                                       SCS     4470
      ACONE=AEPNE*XLP/(NBANK*NEJECT)                                    SCS     4480
      AE=AESHRD*XLP/(NBANK*NEJECT)                                      SCS     4490
```

```
      DCONE=1.12838*SQRT(ACONE)
      ASCONE=4.0*ACONE
      MCONE=8.04311*ASCONE*NEJECT*NBANK
C
      ASTAR=ACONE/AASM(BEP,MEPNE)
      DPLEN=3.56825*SQRT(ASTAR)
      ASPLEN=2.5*ASTAR
      TAU=1.03598E-08*P0EP*DPLEN
      MPLEN=7.91645E+03*TAU*ASPLEN*NEJECT*NBANK
C
      DSTRUT=1.95441*SQRT(ASTAR)
      DMAX=AMAX1(DPLEN,DCONE)
      B=-0.636620*DSTRUT
      C=-DMAX*DMAX+0.636620*DSTRUT*DMAX-5.09296*AE
      DL=(-B+SQRT(B*B-4.0*C))/2.0
      ASSTRT=1.57080*DSTRUT*DL
      TAU=2.07197E-08*P0EP*DSTRUT
      MSTRUT=7.91645E+03*TAU*ASSTRT*NEJECT*NBANK
C
      DE=1.12838*SQRT(AE)
      DF=DE*(1.0+8.0*TAN(SDANGL))
      ASSHRD=3.14159*(DE*(DD+5.0*DE+DL/2.0)+
     -((DD+DL)*SQRT(144.0*DE*DE+(DL-DD)*(DL-DD))+
     -(DL+DE)*SQRT(196.0*DE*DE+(DL-DE)*(DL-DE))+
     -(DE+DF)*SQRT(64.0*DE*DE+(DF-DE)*(DF-DE)))/4.0)
      TAU=AMAX1(1.27000E-03,3.21429E-03*DL)
      MSHRD=7.91645E+03*TAU*ASSHRD*NEJECT*NBANK
C
      LEJECT=LTR1+LTR2+23.5*DE
      MEJECT=MTR+MCONE+MPLEN+MSTRUT+MSHRD
      VEJECT=VTR+3.14159*DF*(DF*(DF+DE)/3.0+DD*(3.0*DD+2.0*DL)/4.0+
     -DE*(26.0*DE+7.0*DL)/12.0+29.0*DL*DL/24.0)*NEJECT*NBANK
C
      LLINE=1.73205*NTANK*(VERT)**(1.0/3.0)+NBANK*(7.0*DF+NEJECT*WBASE)
      MELINE=0.226239*LLINE
      GO TO 115
C
C
C**********************************************************************
C*                                                                    *
C*      CALCULATE THE SUPERSONIC/SUPERSONIC EJECTOR VOLUME/MASS       *
C*                                                                    *
C**********************************************************************
C
C
114   IF(NEJECT.EQ.0.OR.NEJECT.GT.NMAX) NEJECT=NMAX
      AE=AESHRD*XLP/(NBANK*NEJECT)
      DE=1.12838*SQRT(AE)
      WTR=WBASE/NEJECT
      DD=1.12838*SQRT(WTR*DA)
      ASTR=14.0*DA*WTR*DE
      TAU=AMAX1(1.27000E-03,3.75000E-03*DD)
      MTR=7.91645E+03*TAU*ASTR*NEJECT*NBANK
C
      ACONE=AEPNE*XLP/(NBANK*NEJECT)
```

```
      ASTAR=ACONE/AASM(GEP,MEPNE)                                       SCS     5050
      DSTAR=(DE-SQRT(DE*DE-1.27324*ASTAR))/2.0                          SCS     5060
      LCONE=((DE-DD)/2.0-DSTAR)/0.267949                                SCS     5070
      ASCONE=3.14159*(DE*LCONE+(DD+DE-2.0*DSTAR)*SQRT(LCONE*LCONE+      SCS     5080
     -(DE-2.0*DSTAR-DD)**2)/2.0)                                        SCS     5090
      MCONE=10.0539*ASCONE*NEJECT*NBANK                                 SCS     5100
C                                                                       SCS     5110
      DPLEN=3.56825*SQRT(ASTAR)                                         SCS     5120
      C=AMAX1(DE-DPLEN,DA+DPLEN)                                        SCS     5130
      ASPLEN=9.86960*C*DPLEN                                            SCS     5140
      TAU=2.07197E-08*POEP*DPLEN                                        SCS     5150
      MPLEN=7.91645E+03*TAU*ASPLEN*NEJECT*NBANK                         SCS     5160
C                                                                       SCS     5170
      DF=DE*(1.0+8.0*TAN(SDANGL))                                       SCS     5180
      ASSHRD=3.14159*(7.5*DF*DF+(DE+DF)*SQRT(64.0*DE*DE+(DF-DE)*        SCS     5190
     -(DF-DE))/4.0)                                                     SCS     5200
      TAU=AMAX1(1.27000E-03,3.21429E-03*DF)                             SCS     5210
      MSHRD=7.91645E+03*TAU*ASSHRD*NEJECT*NBANK                         SCS     5220
C                                                                       SCS     5230
      LEJECT=18.5*DF                                                    SCS     5240
      MEJECT=MTR+MCONE+MPLEN+MSHRD                                      SCS     5250
      VEJECT=3.14159*DF*(3.625*DE*DE+(DF*DF+DE*DF+DF*DF)/3.0)*NEJECT*   SCS     5260
     -NBANK                                                             SCS     5270
C                                                                       SCS     5280
      LLINE=1.73205*NTANK*(VERT)**(1.0/3.0)+NBANK*(7.0*DF+NEJECT*WBASE) SCS     5290
      MLLINE=0.226239*LLINE                                             SCS     5300
C                                                                       SCS     5310
C                                                                       SCS     5320
C***********************************************************************SCS     5330
C*                                                                     *SCS     5340
C*                     SYSTEM SUMMARY CALCULATIONS                     *SCS     5350
C*                                                                     *SCS     5360
C***********************************************************************SCS     5370
C                                                                       SCS     5380
C                                                                       SCS     5390
115   MLDHDW=MINJ+MCE+MBASE+MCAV+MAW+MCS+MOPT+MDS+MLRREG+MLLINE         SCS     5400
      VLDHDW=VCOMB+VCAV+VAW+VCS+VOPT                                    SCS     5410
      MLDS=MLDHDW+MLRT                                                  SCS     5420
      VLDS=VLDHDW+VLRT                                                  SCS     5430
      LLDS=LCOMB+LCAV                                                   SCS     5440
C                                                                       SCS     5450
      IF(EJECT.EQ.DIF) GO TO 116                                        SCS     5460
      IF(EJECT.EQ.CAE) GO TO 117                                        SCS     5470
      IF(EJECT.EQ.SSE) GO TO 118                                        SCS     5480
      MPRS=0.0                                                          SCS     5490
      VPRS=0.0                                                          SCS     5500
      LPRS=0.0                                                          SCS     5510
      MAXDEV=1.5*DA*NBANK                                               SCS     5520
      GO TO 119                                                         SCS     5530
C                                                                       SCS     5540
116   MPRS=MSUPD+MSUBD                                                  SCS     5550
      VPRS=VSUPD+VSUBD                                                  SCS     5560
      LPRS=LSUPD+LSUBD                                                  SCS     5570
      MAXDEV=1.5*DB*NBANK                                               SCS     5580
      GO TO 119                                                         SCS     5590
```

```
C                                                                       SCS    5600
117   MPRHDW=MSUPD+MSUBD+MEJECT+MERREG+MELINE                           SCS    5610
      VPRHDW=VSUPD+VSUBD+VEJECT                                         SCS    5620
      MPRS=MPRHDW+MERT                                                  SCS    5630
      VPRS=VPRHDW+VERT                                                  SCS    5640
      LPRS=LSUPD+LSUBD+LEJECT                                           SCS    5650
      HBXDEV=1.5*DL*NBANK                                               SCS    5660
      GO TO 119                                                         SCS    5670
C                                                                       SCS    5680
118   MPRHDW=MEJECT+MERREG+MELINE                                       SCS    5690
      MPRS=MPRHDW+MERT                                                  SCS    5700
      VPRS=VEJECT+VERT                                                  SCS    5710
      LPRS=LEJECT                                                       SCS    5720
      HBXDEV=1.5*DE*NBANK                                               SCS    5730
C                                                                       SCS    5740
119   MMISC=AMIN1(362.874,0.1*(MLDS+MPRS))                              SCS    5750
      MTOTAL=MLDS+MPRS+MMISC                                            SCS    5760
      VTOTAL=VLDS+VPRS                                                  SCS    5770
      VSYSTM=2.0*VTOTAL                                                 SCS    5780
      LBXDEV=LLDS+LPRS                                                  SCS    5790
      WBXDEV=1.1*WBASE                                                  SCS    5800
      VBXDEV=LBXDEV*WBXDEV*HBXDEV                                       SCS    5810
C                                                                       SCS    5820
C                                                                       SCS    5830
C***********************************************************************SCS    5840
C*                                                                     *SCS    5850
C*                            OUTPUT RESULTS                           *SCS    5860
C*                                                                     *SCS    5870
C***********************************************************************SCS    5880
C                                                                       SCS    5890
C                                                                       SCS    5900
      CALL OUTSCS                                                       SCS    5910
      GO TO 202                                                         SCS    5920
C                                                                       SCS    5930
C                                                                       SCS    5940
C***********************************************************************SCS    5950
C*                                                                     *SCS    5960
C*                          FAILURE INDICATORS                         *SCS    5970
C*                                                                     *SCS    5980
C***********************************************************************SCS    5990
C                                                                       SCS    6000
C                                                                       SCS    6010
120   WRITE(6,201)                                                      SCS    6020
C                                                                       SCS    6030
C                                                                       SCS    6040
C***********************************************************************SCS    6050
C*                                                                     *SCS    6060
C*                          FORMAT STATEMENTS                          *SCS    6070
C*                                                                     *SCS    6080
C***********************************************************************SCS    6090
C                                                                       SCS    6100
C                                                                       SCS    6110
201   FORMAT(*0*,T2,*SUBROUTINE INSCS WAS CALLED FROM SUBROUTINE SCS*)  SCS    6120
202   END                                                               SCS    6130
```

```
      SUBROUTINE INSCS                                                  INSCS  0100
C                                                                       INSCS  0110
C                                                                       INSCS  0120
C***********************************************************************INSCS  0130
C*                                                                     *INSCS  0140
C*                    INPUT SUBROUTINE (INSCS)                         *INSCS  0150
C*                                                                     *INSCS  0160
C***********************************************************************INSCS  0170
C                                                                       INSCS  0180
C***********************************************************************INSCS  0190
C*                                                                     *INSCS  0200
C* SUBROUTINE INSCS CONTROLS THE INPUT OF INITIAL DATA FOR THE SYSTEM  *INSCS  0210
C* CALCULATION SECTION.                                                *INSCS  0220
C*                                                                     *INSCS  0230
C* INPUT VARIABLES:                                                    *INSCS  0240
C*                                                                     *INSCS  0250
C* EJECT   = PRESSURE RECOVERY SECTION CONTROL VARIABLE                *INSCS  0260
C* N1      = NUMBER OF CARBON ATOMS IN PRIMARY REACTANT 1              *INSCS  0270
C* N2      = NUMBER OF HYDROGEN (DEUTERIUM) ATOMS IN PRIMARY           *INSCS  0280
C*           REACTANT 1                                                *INSCS  0290
C* N3      = NUMBER OF NITROGEN ATOMS IN PRIMARY REACTANT 4            *INSCS  0300
C* N4      = NUMBER OF FLUORINE ATOMS IN PRIMARY REACTANT 4            *INSCS  0310
C* SCSS1   = CONTROL VARIABLE                                          *INSCS  0320
C* SCSS3   = CONTROL VARIABLE                                          *INSCS  0330
C* SCSS4   = CONTROL VARIABLE                                          *INSCS  0340
C* STAW    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2-AW              *INSCS  0350
C* STCS    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2O-CS             *INSCS  0360
C* STC2H4  = STORAGE MODE DESCRIPTOR DATA ARRAY FOR C2H4               *INSCS  0370
C* STD2    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR D2                 *INSCS  0380
C* STF2    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR F2                 *INSCS  0390
C* STHE    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR HE                 *INSCS  0400
C* STH2    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2                 *INSCS  0410
C* STIRFNA = STORAGE MODE DESCRIPTOR DATA ARRAY FOR IRFNA              *INSCS  0420
C* STMMH   = STORAGE MODE DESCRIPTOR DATA ARRAY FOR MMH                *INSCS  0430
C* STNF3   = STORAGE MODE DESCRIPTOR DATA ARRAY FOR NF3                *INSCS  0440
C* STN2    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2                 *INSCS  0450
C* STN2H4  = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2H4               *INSCS  0460
C* WFPR2   = MASS FRACTION OF HE                                       *INSCS  0470
C* WFPR3   = MASS FRACTION OF N2                                       *INSCS  0480
C* WFSR2   = MASS FRACTION OF HE                                       *INSCS  0490
C* WFSR3   = MASS FRACTION OF N2                                       *INSCS  0500
C*                                                                     *INSCS  0510
C* INPUT/OUTPUT VARIABLES:                                             *INSCS  0520
C*                                                                     *INSCS  0530
C* EREACT  = ALPHANUMERIC SYMBOL FOR THE EJECTOR PRIMARY REACTANT      *INSCS  0540
C* FAIL    = ERROR FLAG                                                *INSCS  0550
C* K       = STORAGE MODE CONTROL ARRAY                                *INSCS  0560
C* NBANK   = NUMBER OF LASER BANKS                                     *INSCS  0570
C* NEJECT  = NUMBER OF EJECTORS PER BANK                               *INSCS  0580
C*         = 0, FOR THE MAXIMUM ALLOWABLE                              *INSCS  0590
C* RTIME   = RUN TIME (S)                                              *INSCS  0600
C* SCSS2   = CONTROL VARIABLE                                          *INSCS  0610
C* SETSCS  = CONTROL VARIABLE                                          *INSCS  0620
C* WPP3    = FREE FLUORINE MASS FLOW RATE (KG/S)                       *INSCS  0630
C*                                                                     *INSCS  0640
```

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C* NOTE: ALL INPUT IS IN SI UNITS.                                      *INSCS  0650
C*                                                                      *INSCS  0660
C***********************************************************************INSCS  0670
C                                                                        INSCS  0680
      REAL NO .                                                          INSCS  0690
C                                                                        INSCS  0700
      DIMENSION DESCRI(10),TITLE(10)                                     INSCS  0710
C                                                                        INSCS  0720
      COMMON/CCS3/DFORHF                                                 INSCS  0730
C                                                                        INSCS  0740
      COMMON/CCS5/N1,N2,N3,N4                                            INSCS  0750
C                                                                        INSCS  0760
      COMMON/CCS10/WFPR2,WFPR3,WFSR2,WFSR3                               INSCS  0770
C                                                                        INSCS  0780
      COMMON/MAIN1/FAIL                                                  INSCS  0790
C                                                                        INSCS  0800
      COMMON/MAIN6/SETSCS                                                INSCS  0810
C                                                                        INSCS  0820
      COMMON/PRS5/EJECT                                                  INSCS  0830
C                                                                        INSCS  0840
      COMMON/SCS1/SCSS2                                                  INSCS  0850
C                                                                        INSCS  0860
      COMMON/SCS2/EREACT,NBANK,NEJECT,RTIME,WPP3                         INSCS  0870
C                                                                        INSCS  0880
      COMMON/SCS4/K(10)                                                  INSCS  0890
C                                                                        INSCS  0900
      COMMON/SCS5/STMODE(10,10)                                          INSCS  0910
C                                                                        INSCS  0920
C                                                                        INSCS  0930
      COMMON/SCS6/STAW(10,4)                                             INSCS  0940
      COMMON/SCS7/STCS(10,5)                                             INSCS  0950
      COMMON/SCS8/STC2H4(10,2)                                           INSCS  0960
      COMMON/SCS9/STO2(10,4)                                             INSCS  0970
      COMMON/SCS10/STF2(10,4)                                            INSCS  0980
      COMMON/SCS11/STHE(10,4)                                            INSCS  0990
      COMMON/SCS12/STH2(10,4)                                            INSCS  1000
      COMMON/SCS13/STIRFNA(10,4)                                         INSCS  1010
      COMMON/SCS14/STMMH(10,4)                                           INSCS  1020
      COMMON/SCS15/STNF3(10,4)                                           INSCS  1030
      COMMON/SCS16/STN2(10,8)                                            INSCS  1040
      COMMON/SCS17/STN2H4(10,4)                                          INSCS  1050
C                                                                        INSCS  1060
      DATA (DESCRI(I),I=1,10)/10HREACT     ,10HPHASE     ,               INSCS  1070
     -10HCONT      ,10HSTEMP     ,10HSTIME     ,10H          ,           INSCS  1080
     -10HSPRES     ,10H          ,10HRFSYS     ,10HMATER     /           INSCS  1090
C                                                                        INSCS  1100
      DATA (TITLE(K),K=1,10)/10HK          ,10H1          ,10H2         , INSCS  1110
     -10H3         ,10H4         ,10HK         ,10H5         ,           INSCS  1120
     -10H6         ,10H7         ,10H8         /                         INSCS  1130
C                                                                        INSCS  1140
      DATA CAE/3HCAE/,DF/2HDF/,NO/2HNO/,SSE/3HSSE/,YES/3HYES/            INSCS  1150
C                                                                        INSCS  1160
      NAMELIST/NLSCS/NBANK,NEJECT,RTIME,WPP3                             INSCS  1170
C                                                                        INSCS  1180
C                                                                        INSCS  1190
```

```
C***********************************************************************INSCS  1200
C*                                                                     *INSCS  1210
C*                         SET DEFAULT VALUES                          *INSCS  1220
C*                                                                     *INSCS  1230
C***********************************************************************INSCS  1240
C                                                                       INSCS  1250
C                                                                       INSCS  1260
      IF(SETSCS.EQ.NO) GO TO 102                                        INSCS  1270
      EREACT=10HIRFNA/MMH                                               INSCS  1280
      K(2)=1                                                            INSCS  1290
      K(3)=1                                                            INSCS  1300
      K(4)=1                                                            INSCS  1310
      K(5)=1                                                            INSCS  1320
      K(6)=1                                                            INSCS  1330
      K(7)=1                                                            INSCS  1340
      K(8)=1                                                            INSCS  1350
      K(9)=1                                                            INSCS  1360
      K(10)=1                                                           INSCS  1370
      NBANK=1                                                           INSCS  1380
      NEJECT=1                                                          INSCS  1390
      RTIME=60.0                                                        INSCS  1400
      SCSS2=YES                                                         INSCS  1410
      DO 101 I=1,10                                                     INSCS  1420
101   STMODE(I,1)=DESCRI(I)                                             INSCS  1430
      WPP3=1.89645                                                      INSCS  1440
      SETSCS=NO                                                         INSCS  1450
C                                                                       INSCS  1460
C                                                                       INSCS  1470
C***********************************************************************INSCS  1480
C*                                                                     *INSCS  1490
C*                         CONTROL STATEMENTS                          *INSCS  1500
C*                                                                     *INSCS  1510
C***********************************************************************INSCS  1520
C                                                                       INSCS  1530
C                                                                       INSCS  1540
102   WRITE(6,310)                                                      INSCS  1550
      READ(5,304)SCSS1                                                  INSCS  1560
      IF(SCSS1.EQ.NO) RETURN                                            INSCS  1570
      WRITE(6,311)                                                      INSCS  1580
      READ(5,304)SCSS2                                                  INSCS  1590
      IF(SCSS2.EQ.NO) RETURN                                            INSCS  1600
      WRITE(6,312)                                                      INSCS  1610
      READ(5,304)SCSS3                                                  INSCS  1620
      IF(SCSS3.EQ.NO) GO TO 103                                         INSCS  1630
      REWIND 4                                                          INSCS  1640
      READ(4)EREACT,(K(I),I=2,10),NBANK,NEJECT,RTIME,SCSS2,WPP3         INSCS  1650
      RETURN                                                            INSCS  1660
103   WRITE(6,313)                                                      INSCS  1670
      IF(EJECT.NE.CAE.AND.EJECT.NE.SSE) WRITE(6,314)NBANK,RTIME,WPP3    INSCS  1680
      IF(EJECT.EQ.CAE.OR.EJECT.EQ.SSE) WRITE(6,315)NBANK,NEJECT,RTIME,  INSCS  1690
     -WPP3                                                              INSCS  1700
      READ(5,NLSCS)                                                     INSCS  1710
      WRITE(6,316)                                                      INSCS  1720
      READ(5,304)SCSS4                                                  INSCS  1730
      IF(SCSS4.EQ.NO) GO TO 118                                         INSCS  1740
```

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C                                                                       INSCS 1750
C                                                                       INSCS 1760
C***********************************************************************INSCS 1770
C*                                                                     *INSCS 1780
C*      LASER PRIMARY & SECONDARY REACTANT STORAGE MODE SELECTION      *INSCS 1790
C*                                                                     *INSCS 1800
C***********************************************************************INSCS 1810
C                                                                       INSCS 1820
C                                                                       INSCS 1830
      WRITE(6,317)                                                      INSCS 1840
      IF(DFORHF.EQ.DF) GO TO 105                                        INSCS 1850
      IF(N1.EQ.0.AND.N2.EQ.2) GO TO 104                                 INSCS 1860
      GO TO 119                                                         INSCS 1870
104   WRITE(6,320)STD2(1,1)                                             INSCS 1880
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STD2(I,L),L=1,4),      INSCS 1890
     -I=2,10)                                                           INSCS 1900
      GO TO 108                                                         INSCS 1910
105   IF(N1.EQ.2.AND.N2.EQ.4) GO TO 106                                 INSCS 1920
      IF(N1.EQ.0.AND.N2.EQ.2) GO TO 107                                 INSCS 1930
      GO TO 120                                                         INSCS 1940
106   WRITE(6,320)STC2H4(1,1)                                           INSCS 1950
      WRITE(6,307)(TITLE(L),L=1,3),(STMODE(I,1),(STC2H4(I,L),L=1,2),    INSCS 1960
     -I=2,10)                                                           INSCS 1970
      GO TO 108                                                         INSCS 1980
107   WRITE(6,320)STH2(1,1)                                             INSCS 1990
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STH2(I,L),L=1,4),      INSCS 2000
     -I=2,10)                                                           INSCS 2010
108   READ(5,303)K(2)                                                   INSCS 2020
      IF(N3.EQ.1.AND.N4.EQ.3) GO TO 109                                 INSCS 2030
      IF(N3.EQ.0.AND.N4.EQ.2) GO TO 110                                 INSCS 2040
      GO TO 121                                                         INSCS 2050
109   WRITE(6,320)STNF3(1,1)                                            INSCS 2060
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STNF3(I,L),L=1,4),     INSCS 2070
     -I=2,10)                                                           INSCS 2080
      GO TO 111                                                         INSCS 2090
110   WRITE(6,320)STF2(1,1)                                             INSCS 2100
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STF2(I,L),L=1,4),      INSCS 2110
     -I=2,10)                                                           INSCS 2120
111   READ(5,303)K(5)                                                   INSCS 2130
      IF(K(5).LT.3.AND.WFSR2.EQ.0.0) GO TO 112                          INSCS 2140
      IF(WFPR2.EQ.0.0.AND.WFSR2.EQ.0.0) GO TO 112                       INSCS 2150
      WRITE(6,320)STHE(1,1)                                             INSCS 2160
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STHE(I,L),L=1,4),      INSCS 2170
     -I=2,10)                                                           INSCS 2180
      READ(5,303)K(3)                                                   INSCS 2190
112   IF(WFPR3.EQ.0.0.AND.WFSR3.EQ.0.0) GO TO 113                       INSCS 2200
      WRITE(6,320)STN2(1,1)                                             INSCS 2210
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STN2(I,L),L=1,4),      INSCS 2220
     -I=2,10)                                                           INSCS 2230
      WRITE(6,309)(TITLE(L),L=6,10),(STMODE(I,1),(STN2(I,L),L=5,8),     INSCS 2240
     -I=2,10)                                                           INSCS 2250
      READ(5,303)K(4)                                                   INSCS 2260
113   IF(DFORHF.EQ.DF) GO TO 114                                        INSCS 2270
      WRITE(6,320)STH2(1,1)                                             INSCS 2280
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STH2(I,L),L=1,4),      INSCS 2290
```

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     -I=2,10)                                                           INSCS  2300
      GO TO 115                                                         INSCS  2310
114   WRITF(6,320)STD2(1,1)                                             INSCS  2320
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STD2(I,L),L=1,4),      INSCS  2330
     -I=2,10)                                                           INSCS  2340
115   READ(5,303)K(6)                                                   INSCS  2350
C                                                                       INSCS  2360
C                                                                       INSCS  2370
C***********************************************************************INSCS  2380
C*                                                                     *INSCS  2390
C*                AERO-WINDOW FLUID STORAGE MODE SFLECTION             *INSCS  2400
C*                                                                     *INSCS  2410
C***********************************************************************INSCS  2420
C                                                                       INSCS  2430
C                                                                       INSCS  2440
      kRITE(6,318)                                                      INSCS  2450
      WRITE(6,320)STAW(1,1)                                             INSCS  2460
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STAW(I,L),L=1,4),      INSCS  2470
     -I=2,10)                                                           INSCS  2480
      READ(5,303)K(7)                                                   INSCS  2490
C                                                                       INSCS  2500
C                                                                       INSCS  2510
C***********************************************************************INSCS  2520
C*                                                                     *INSCS  2530
C*               COOLING SYSTFM FLUID STORAGE MODF SFLECTION           *INSCS  2540
C*                                                                     *INSCS  2550
C***********************************************************************INSCS  2560
C                                                                       INSCS  2570
C                                                                       INSCS  2580
      WRITE(6,319)                                                      INSCS  2590
      WRITE(6,320)STCS(1,1)                                             INSCS  2600
      WRITE(6,301)                                                      INSCS  2610
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STCS(I,L),L=1,4),      INSCS  2620
     -I=2,10)                                                           INSCS  2630
      WRITE(6,302)                                                      INSCS  2640
      WRITE(6,306)(TITLE;L),L=6,7),(STMODE(I,1),STCS(I,5),I=2,10)       INSCS  2650
      READ(5,303)K(8)                                                   INSCS  2660
C                                                                       INSCS  2670
C                                                                       INSCS  2680
C***********************************************************************INSCS  2690
C*                                                                     *INSCS  2700
C*            EJECTOR PRIMARY REACTANT STORAGE MODE SELECTION          *INSCS  2710
C*                                                                     *INSCS  2720
C***********************************************************************INSCS  2730
C                                                                       INSCS  2740
C                                                                       INSCS  2750
      IF(EJECT.NE.CAE.AND.FJECT.NE.SSE) GO TO 118                       INSCS  2760
      WRITE(6,321)                                                      INSCS  2770
      READ(5,305)EREACT                                                 INSCS  2780
      IF(EREACT.EQ.10HN2H4       ) GO TO 116                            INSCS  2790
      IF(EREACT.EQ.10HIRFNA/MMH  ) GO TO 117                            INSCS  2800
      GO TC 122                                                         INSCS  2810
116   WRITE(6,320)STN2H4(1,1)                                           INSCS  2820
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STN2H4(I,L),L=1,4),    INSCS  2830
     -I=2,10)                                                           INSCS  2840
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      READ(5,303)K(9)                                                   INSCS  2850
      RETURN                                                            INSCS  2860
117   WRITE(6,320)STMMH(1,1)                                            INSCS  2870
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STMMH(I,L),L=1,4),     INSCS  2880
     -I=2,10)                                                           INSCS  2890
      READ(5,303)K(9)                                                   INSCS  2900
      WRITE(6,320)STIRFNA(1,1)                                          INSCS  2910
      WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STIRFNA(I,L),L=1,4),   INSCS  2920
     -I=2,10)                                                           INSCS  2930
      READ(3,303)K(10)                                                  INSCS  2940
118   REWIND 4                                                          INSCS  2950
      WRITE(4)EREACT,(K(I),I=2,10),NBANK,NEJECT,RTIME,SCSS2,WPP3        INSCS  2960
      RETURN                                                            INSCS  2970
C                                                                       INSCS  2980
C                                                                       INSCS  2990
C***********************************************************************INSCS  3000
C*                                                                     *INSCS  3010
C*                          FAILURE INDICATORS                         *INSCS  3020
C*                                                                     *INSCS  3030
C***********************************************************************INSCS  3040
C                                                                       INSCS  3050
C                                                                       INSCS  3060
119   WRITE(6,201)N1,N2                                                 INSCS  3070
      GO TO 123                                                         INSCS  3080
120   WRITE(6,202)N1,N2                                                 INSCS  3090
      GO TO 123                                                         INSCS  3100
121   WRITE(6,203)N3,N4                                                 INSCS  3110
      GO TO 123                                                         INSCS  3120
122   WRITE(6,204)EREACT                                                INSCS  3130
123   FAIL=YES                                                          INSCS  3140
C                                                                       INSCS  3150
C                                                                       INSCS  3160
C***********************************************************************INSCS  3170
C*                                                                     *INSCS  3180
C*                          FORMAT STATEMENTS                          *INSCS  3190
C                                                                      *INSCS  3200
C***********************************************************************INSCS  3210
C                                                                       INSCS  3220
C                                                                       INSCS  3230
201   FORMAT(*1*,T2,*NO TANK VOLUME/MASS SUBROUTINE EXITS FOR C*,I1,*D*,INSCS  3240
     -I1,/,T2,*PROGRAM TERMINATED IN SUBROUTINE INSCS*)                 INSCS  3250
202   FORMAT(*1*,T2,*NO TANK VOLUME/MASS SUBROUTINE EXITS FOR C*,I1,*H*,INSCS  3260
     -I1,/,T2,*PROGRAM TERMINATED IN SUBROUTINE INSCS*)                 INSCS  3270
203   FORMAT(*1*,T2,*NO TANK VOLUME/MASS SUBROUTINE EXITS FOR N*,I1,*F*,INSCS  3280
     -I1,/,T2,*PROGRAM TERMINATED IN SUBROUTINE INSCS*)                 INSCS  3290
204   FORMAT(*1*,T2,*NO TANK VOLUME/MASS SUBROUTINE EXITS FOR *,A10,/,  INSCS  3300
     -T2,*PROGRAM TERMINATED IN SUBROUTINE INSCS*)                      INSCS  3310
301   FORMAT(*Q*)                                                       INSCS  3320
302   FORMAT(*R*)                                                       INSCS  3330
303   FORMAT(I1)                                                        INSCS  3340
304   FORMAT(A3)                                                        INSCS  3350
305   FORMAT(A10)                                                       INSCS  3360
306   FORMAT(*1*,9(T2,2A12,/),T2,2A12)                                  INSCS  3370
307   FORMAT(* *,9(T2,3A12,/),T2,3A12)                                  INSCS  3380
308   FORMAT(* *,9(T2,5A12,/),T2,5A12)                                  INSCS  3390
```

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309    FORMAT(*1*,9(T2,5A12,/),T2,5A12)                                    INSCS   3400
310    FORMAT(*1*,T2,*ARE NEW SYSTEM CALCULATION INPUTS REQUIRED?*,/)      INSCS   3410
311    FORMAT(*1*,T2,*ARE SYSTEM CALCULATIONS DESIRED?*,/)                 INSCS   3420
312    FORMAT(*0*,T2,*SHOULD INPUT DATA BE READ FROM TAPE5?*,/)            INSCS   3430
313    FORMAT(*1*,T2,*INPUT DATA FOR THE SYSTEM CALCULATION SECTION BY NAINSCS   3440
      -MELIST,*,/,T2,*CURRENT VALUES ARE:*)                                INSCS   3450
314    FORMAT(* *,T2,*$NLSCS*,T26,*NBANK   =*,I13,T50,*RTIME   =*,E13.6, INSCS   3460
      -/,T2,*WPP3    =*,E13.6,* $*,/)                                      INSCS   3470
315    FORMAT(* *,T2,*$NLSCS*,T26,*NBANK   =*,I13,T50,*NEJECT  =*,I13,/, INSCS   3480
      -T2,*RTIME   =*,E13.6,T26,*WPP3    =*,E13.6,* $*,/)                  INSCS   3490
316    FORMAT(*1*,T2,*ARE NEW REACTANT STORAGE MODES REQUIRED?*,/)         INSCS   3500
317    FORMAT(*1*,//////,T2,*LASER PRIMARY & SECONDARY REACTANT STORAGE IINSCS   3510
      -NPUT SECTION*)                                                      INSCS   3520
318    FORMAT(*1*,//////,T2,*AERO-WINDOW FLUID STORAGE INPUT SECTION*)     INSCS   3530
319    FORMAT(*1*,//////,T2,*COOLING SYSTEM FLUID STORAGE INPUT SECTION*)INSCS   3540
320    FORMAT(*1*,T2,A6,* MAY BE STORED ANY OF THE FOLLOWING WAYS.  INPUTINSCS   3550
      - K,*)                                                               INSCS   3560
321    FORMAT(*1*,T2,*INPUT THE EJECTOR PRIMARY REACTANT FROM THE FOLLOWIINSCS   3570
      -NG LIST:*,//,T2,*"N2H4" FOR A MONOPROPELLANT DRIVER*,/,T2,          INSCS   3580
      -*"IRFNA/MMH" FOR A BIPROPELLANT DRIVER*,/)                          INSCS   3590
       END                                                                 INSCS   3600
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```
      SUBROUTINE OUTSCS                                                 OUTSCS 0100
C                                                                       OUTSCS 0110
C                                                                       OUTSCS 0120
C***********************************************************************OUTSCS 0130
C*                                                                     *OUTSCS 0140
C*                     OUTPUT SUBROUTINE (OUTSCS)                      *OUTSCS 0150
C*                                                                     *OUTSCS 0160
C***********************************************************************OUTSCS 0170
C                                                                       OUTSCS 0180
C***********************************************************************OUTSCS 0190
C*                                                                     *OUTSCS 0200
C*   SUBROUTINE OUTSCS PRINTS THE SYSTEM CALCULATION SECTION RESULTS   *OUTSCS 0210
C*   OF PROGRAM CLAP IN SI UNITS ON TERMINALS  WITH A MINIMUM OF 132   *OUTSCS 0220
C*   CHARACTERS PER LINE.                                              *OUTSCS 0230
C*                                                                     *OUTSCS 0240
C***********************************************************************OUTSCS 0250
C                                                                       OUTSCS 0260
C                                                                       OUTSCS 0270
      IMPLICIT REAL(L,M)                                                OUTSCS 0280
C                                                                       OUTSCS 0290
      REAL NO                                                           OUTSCS 0300
C                                                                       OUTSCS 0310
      COMMON/PRS5/EJECT                                                 OUTSCS 0320
C                                                                       OUTSCS 0330
      COMMON/SCS2/EREACT,NBANK,NEJECT,RTIME,WPP3                        OUTSCS 0340
C                                                                       OUTSCS 0350
      COMMON/SCS3/HBXDEV,LBXDEV,LLDS,LPRS,MAW,MBASE,MCAV,MCB,MCS,MDS,   OUTSCS 0360
     -MEJECT,MELINE,MERREG,MERT,MINJ,MLDHDW,MLDS,MLLINE,MLRREG,MLRT,    OUTSCS 0370
     -MMISC,MOPT,MPRHDW,MPRS,MSUBD,MSUPD,MTOTAL,VAW,VBXDEV,VCAV,VCOMB,  OUTSCS 0380
     -VCS,VEJECT,VERT,VLDHDW,VLDS,VLRT,VOPT,VPRHDW,VPRS,VSUBD,VSUPD,    OUTSCS 0390
     -VSYSTM,VTOTAL,WBASE,WBXDEV,XLP                                    OUTSCS 0400
C                                                                       OUTSCS 0410
      COMMON/SCS5/STMODE(10,10)                                         OUTSCS 0420
C                                                                       OUTSCS 0430
      DATA CAE/3HCAE/,NO/2HNO/,SSE/3HSSE/                               OUTSCS 0440
C                                                                       OUTSCS 0450
C                                                                       OUTSCS 0460
C***********************************************************************OUTSCS 0470
C*                                                                     *OUTSCS 0480
C*                         OUTPUT INITIAL DATA                         *OUTSCS 0490
C*                                                                     *OUTSCS 0500
C***********************************************************************OUTSCS 0510
C                                                                       OUTSCS 0520
C                                                                       OUTSCS 0530
      WRITE(20,201)                                                     OUTSCS 0540
      IF(EJECT.NE.CAE.AND.EJECT.NE.SSE) WRITE(20,202)NBANK,RTIME,WPP3   OUTSCS 0550
      IF(EJECT.EQ.CAE.OR.EJECT.EQ.SSE) WRITE(20,203)EREACT,NBANK,NEJECT,OUTSCS 0560
     -RTIME,WPP3                                                        OUTSCS 0570
      WRITE(20,204)((STMODE(I,J),J=1,6),I=1,10),(STMODE(I,1),           OUTSCS 0580
     -(STMODE(I,J),J=7,10),I=1,10)                                      OUTSCS 0590
C                                                                       OUTSCS 0600
C                                                                       OUTSCS 0610
C***********************************************************************OUTSCS 0620
C*                                                                     *OUTSCS 0630
C*                        OUTPUT RESULTANT DATA                        *OUTSCS 0640
```

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C*                                                                     *OUTSCS 0650
C***********************************************************************OUTSCS 0660
C                                                                       OUTSCS 0670
C                                                                       OUTS S 0680
      WRITE(20,205)XLP                                                  OUTSCS 0690
      WRITE(20,206)MINJ,MCB,MBASE,VCOMB,MCAV,VCAV,MAW,VAW,MCS,VCS,MOPT, OUTSCS 0700
     -VOPT,MDS,MLRREG,MLLINE,MLDHDW,VLDHDW,MLRT,VLRT,MLDS,VLDS          OUTSCS 0710
      IF(EJECT.EQ.NO) GO TO 104                                         OUTSCS 0720
      IF(EJECT.EQ.CAE) GO TO 101                                        OUTSCS 0730
      IF(EJECT.EQ.SSE) GO TO 102                                        OUTSCS 0740
      WRITE(20,207)MSUPD,VSUPD,MSUBD,VSUBD,MPRS,VPRS                    OUTSCS 0750
      GO TO 103                                                         OUTSCS 0760
101   WRITE(20,208)MSUPD,VSUPD,MSUBD,VSUBD,MEJECT,VEJECT,MERREG,MELINE, OUTSCS 0770
     -MPRHDW,VPRHDW,MERT,VERT,MPRS,VPRS                                 OUTSCS 0780
      GO TO 103                                                         OUTSCS 0790
102   WRITE(20,209)MEJECT,VEJECT,MERREG,MELINE,MPRHDW,MERT,VERT,MPRS,   OUTSCS 0800
     -VPRS                                                              OUTSCS 0810
103   WRITE(20,210)MLDS,VLDS,MPRS,VPRS,MMISC,MTOTAL,VTOTAL,VSYSTM,WBASE,OUTSCS 0820
     -LLDS,LPRS,LBXDEV,WBXDEV,HBXDEV,VBXDEV                             OUTSCS 0830
      RETURN                                                            OUTSCS 0840
104   WRITE(20,211)MLDS,VLDS,MMISC,MTOTAL,VTOTAL,VSYSTM,WBASE,LLDS,     OUTSCS 0850
     -LBXDEV,WBXDEV,HBXDEV,VBXDEV                                       OUTSCS 0860
C                                                                       OUTSCS 0870
C                                                                       OUTSCS 0880
C***********************************************************************OUTSCS 0890
C*                                                                     *OUTSCS 0900
C*                          FORMAT STATEMENTS                          *OUTSCS 0910
C*                                                                     *OUTSCS 0920
C***********************************************************************OUTSCS 0930
C                                                                       OUTSCS 0940
C                                                                       OUTSCS 0950
201   FORMAT(*1*,T53,*SYSTEM CALCULATION SECTION*,//,T60,*INITIAL DATA:*OUTSCS 0960
     -)                                                                 OUTSCS 0970
202   FORMAT(*0*,T32,*NBANK   =*,I13,T66,*RTIME   =*,E13.6,* S*,/,      OUTSCS 0980
     -T32,*WPP3    =*,E13.6,* KG/S*)                                    OUTSCS 0990
203   FORMAT(*0*,T32,*EREACT  =*,A13,T66,*NBANK   =*,I13,/,             OUTSCS 1000
     -T32,*NEJECT  =*,I13,T66,*RTIME   =*,E13.6,* S*,/,                 OUTSCS 1010
     -T32,*WPP3    =*,E13.6,* KG/S*)                                    OUTSCS 1020
204   FORMAT(*0*,T55,*REACTANT STORAGE METHOD*,//,10(T32,6A11,/),       OUTSCS 1030
     -10(/,T32,5A11))                                                   OUTSCS 1040
205   FORMAT(*0*,T59,*RESULTANT DATA:*,//,T55,*SYSTEM SCALE-UP FACTOR*, OUTSCS 1050
     -//,T32,*XLP     =*,E13.6,* KMOLE/S*)                              OUTSCS 1060
206   FORMAT(*0*,T51,*LASER DEVICE SYSTEM VOLUME/MASS*,//,              OUTSCS 1070
     -T32,*MINJ    =*,E13.6,* KG*,/,T32,*MCB     =*,E13.6,* KG*,/,      OUTSCS 1080
     -T32,*MBASE   =*,E13.6,* KG*,T66,*VCOMB   =*,E13.6,* M3*,/,        OUTSCS 1090
     -T32,*MCAV    =*,E13.6,* KG*,T66,*VCAV    =*,E13.6,* M3*,/,        OUTSCS 1100
     -T32,*MAW     =*,E13.6,* KG*,T66,*VAW     =*,E13.6,* M3*,/,        OUTSCS 1110
     -T32,*MCS     =*,E13.6,* KG*,T66,*VCS     =*,E13.6,* M3*,/,        OUTSCS 1120
     -T32,*MOPT    =*,E13.6,* KG*,T66,*VOPT    =*,E13.6,* M3*,/,        OUTSCS 1130
     -T32,*MDS     =*,E13.6,* KG*,/,T32,*MLRREG  =*,E13.6,* KG*,/,      OUTSCS 1140
     -T32,*MLLINE  =*,E13.6,* KG*,/,T43,*___________*,                  OUTSCS 1150
     -T77,*___________*,/,T32,*MLDHDW  =*,E13.6,* KG*,                  OUTSCS 1160
     -T66,*VLDHDW  =*,E13.6,* M3*,/,T32,*MLRT    =*,E13.6,* KG*,        OUTSCS 1170
     -T66,*VLRT    =*,E13.6,* M3*,/,T43,*-----------*,                  OUTSCS 1180
     -T77,*___________*,/,T32,*MLDS    =*,E13.6,* KG*,                  OUTSCS 1190
```

```
     -T66,*VLDS     =*,E13.6,* M3*)                                    OUTSCS 1200
207   FORMAT(*1*,T48,*PRESSURE RECOVERY SYSTEM VOLUME/MASS*,//,        OUTSCS 1210
     -T32,*MSUPD    =*,E13.6,* KG*,T66,*VSUPD    =*,E13.6,* M3*,/,     OUTSCS 1220
     -T32,*MSUBD    =*,E13.6,* KG*,T66,*VSUBD    =*,E13.6,* M3*,/,     OUTSCS 1230
     -T43,*___________*,T77,*___________*,/,                           OUTSCS 1240
     -T32,*MPRS     =*,E13.6,* KG*,T66,*VPRS     =*,E13.6,* M3*)       OUTSCS 1250
208   FORMAT(*1*,T48,*PRESSURE RECOVERY SYSTEM VOLUME/MASS*,//,        OUTSCS 1260
     -T32,*MSUPD    =*,E13.6,* KG*,T66,*VSUPD    =*,E13.6,* M3*,/,     OUTSCS 1270
     -T32,*MSUBD    =*,E13.6,* KG*,T66,*VSUBD    =*,E13.6,* M3*,/,     OUTSCS 1280
     -T32,*MEJECT   =*,E13.6,* KG*,T66,*VEJECT   =*,E13.6,* M3*,/,     OUTSCS 1290
     -T32,*MERREG   =*,E13.6,* KG*,/,T32,*MELINE   =*,E13.6,* KG*,/,   OUTSCS 1300
     -T43,*___________*,T77,*___________*,/,                           OUTSCS 1310
     -T32,*MPRHDW   =*,E13.6,* KG*,T66,*VPRHDW   =*,E13.6,* M3*,/,     OUTSCS 1320
     -T32,*MERT     =*,E13.6,* KG*,T66,*VERT     =*,E13.6,* M3*,/,     OUTSCS 1330
     -T43,*___________*,T77,*___________*,/,                           OUTSCS 1340
     -T32,*MPRS     =*,E13.6,* KG*,T66,*VPRS     =*,E13.6,* M3*)       OUTSCS 1350
209   FORMAT(*1*,T48,*PRESSURE RECOVERY SYSTEM VOLUME/MASS*,//,        OUTSCS 1360
     -T32,*MEJECT   =*,E13.6,* KG*,T66,*VEJECT   =*,E13.6,* M3*,/,     OUTSCS 1370
     -T32,*MERREG   =*,E13.6,* KG*,/,T32,*MELINE   =*,E13.6,* KG*,/,   OUTSCS 1380
     -T43,*___________*,/,T32,*MPRHDW   =*,E13.6,* KG*,/,              OUTSCS 1390
     -T32,*MERT     =*,E13.6,* KG*,T66,*VERT     =*,E13.6,* M3*,/,     OUTSCS 1400
     -T43,*___________*,T77,*___________*,/,                           OUTSCS 1410
     -T32,*MPRS     =*,E13.6,* KG*,T66,*VPRS     =*,E13.6,* M3*)       OUTSCS 1420
210   FORMAT(*0*,T53,*SYSTEM VOLUME/MASS SUMMARY*,//,                  OUTSCS 1430
     -T32,*MLDS     =*,E13.6,* KG*,T66,*VLDS     =*,E13.6,* M3*,/,     OUTSCS 1440
     -T32,*MPRS     =*,E13.6,* KG*,T66,*VPRS     =*,E13.6,* M3*,/,     OUTSCS 1450
     -T32,*MMISC    =*,E13.6,* KG*,/,T43,*___________*,                OUTSCS 1460
     -T77,*___________*,/,T32,*MTOTAL   =*,E13.6,* KG*,                OUTSCS 1470
     -T66,*VTOTAL   =*,E13.6,* M3*,/,T66,*VSYSTM   =*,E13.6,* M3*,//,  OUTSCS 1480
     -T32,*WBASE    =*,E13.6,* M*,T66,*LLDS     =*,E13.6,* M*,/,       OUTSCS 1490
     -T32,*LPRS     =*,E13.6,* M*,//,T32,*LBXDEV   =*,E13.6,* M*,      OUTSCS 1500
     -T66,*WBXDEV   =*,E13.6,* M*,/,T32,*HBXDEV   =*,E13.6,* M*,       OUTSCS 1510
     -T66,*VBXDEV   =*,E13.6,* M3*)                                    OUTSCS 1520
211   FORMAT(*1*,T53,*SYSTEM VOLUME/MASS SUMMARY*,//,                  OUTSCS 1530
     -T32,*MLDS     =*,E13.6,* KG*,T66,*VLDS     =*,E13.6,* M3*,/,     OUTSCS 1540
     -T32,*MMISC    =*,E13.6,* KG*,/,T43,*___________*,                OUTSCS 1550
     -T77,*___________*,/,T32,*MTOTAL   =*,E13.6,* KG*,                OUTSCS 1560
     -T66,*VTOTAL   =*,E13.6,* M3*,/,T66,*VSYSTM   =*,E13.6,* M3*,//,  OUTSCS 1570
     -T32,*WBASE    =*,E13.6,* M*,T66,*LLDS     =*,E13.6,* M*,//,      OUTSCS 1580
     -T32,*LBXDEV   =*,E13.6,* M*,T66,*WBXDEV   =*,E13.6,* M*,/,       OUTSCS 1590
     -T32,*HBXDEV   =*,E13.6,* M*,T66,*VBXDEV   =*,E13.6,* M3*)        OUTSCS 1600
      END                                                              OUTSCS 1610
```

```
      SUBROUTINE VMAW(J,MN2,RTIME,MTANK,VTANK)
C
C
C***********************************************************************
C*                                                                     *
C*             AERO-WINDOW TANK VOLUME/MASS SUBROUTINE (VMAW)          *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C*     SUBROUTINE VMAW CALCULATES THE N2 TANK VOLUME/MASS FOR THE      *
C*     AERO-WINDOW.                                                    *
C*                                                                     *
C*  N2 FOR THE AERO-WINDOW MAY BE STORED ANY OF FOUR WAYS:             *
C*                                                                     *
C*    K       1              2              3              4           *
C*    PHASE   GAS            GAS            LIQ            LIQ         *
C*    CONT    SPH            CYL            SPH            SPH         *
C*    STEMP   300.0 K        300.0 K        77.5 K         77.5 K      *
C*    STIME   INFINITE       INFINITE       8.6E+05 S      1.6E+07 S   *
C*                                          (10 DAY)       (180 DAY)   *
C*    SPRES   4.1E+07 PA     4.1E+07 PA     1.5E+06 PA     1.5E+06 PA  *
C*            (6000 PSI)     (6000 PSI)     (220 PSI)      (220 PSI)   *
C*    RFSYS   BLD            BLD            HPS            HPS         *
C*    MATER   TI             TI             SS             SS          *
C*                                                                     *
C*  INPUT VARIABLES:                                                   *
C*                                                                     *
C*  J      = STORAGE MODE CONTROL VARIABLE                             *
C*  K      = STORAGE MODE CONTROL ARRAY                                *
C*  MN2    = TOTAL DELIVERED MASS OF N2 [KG]                           *
C*  RTIME  = RUN TIME [S]                                              *
C*                                                                     *
C*  OUTPUT VARIABLES:                                                  *
C*                                                                     *
C*  MTANK  = TANK MASS [KG]                                            *
C*  STAW   = STORAGE MODE DESCRIPTOR DATA ARRAY                        *
C*  STMODE = STORAGE MODE DESCRIPTOR ARRAY                             *
C*  VTANK  = TANK VOLUME [M3]                                          *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
C
      COMMON/SCS4/K(10)
C
      COMMON/SCS5/STMODE(10,10)
C
      COMMON/SCS6/STAW(10,4)
C
      DATA ((STAW(I,K),K=1,4),I=1,10)/
     -10HMN2-AW     ,10HMN2-AW     ,10HMN2-AW     ,10HMN2-AW     ,
     -10HGAS        ,10HGAS        ,10HLIQ        ,10HLIQ        ,
```

```
     -10HSPH       ,10HCYL       ,10HSPH       ,10HSPH       ,          VMAW   0650
     -10H300.0 K   ,10H300.0 K   ,10H77.5 K    ,10H77.5 K    ,          VMAW   0660
     -10HINFINITE  ,10HINFINITE  ,10H8.6E+05 S ,10H1.6E+07 S ,          VMAW   0670
     -10H          ,10H          ,10H(10 DAY)  ,10H(180 DAY) ,          VMAW   0680
     -10H4.1E+07 PA,10H4.1E+07 PA,10H1.5E+06 PA,10H1.5E+06 PA,          VMAW   0690
     -10H(6000 PSI),10H(6000 PSI),10H(220 PSI) ,10H(220 PSI) ,          VMAW   0700
     -10HBLD       ,10HBLD       ,10HHPS       ,10HHPS       ,          VMAW   0710
     -10HTI        ,10HTI        ,10HSS        ,10HSS        /          VMAW   0720
C                                                                       VMAW   0730
C                                                                       VMAW   0740
C***********************************************************************VMAW   0750
C*                                                                     *VMAW   0760
C*                 SET STORAGE MODE DESCRIPTOR ARRAY                   *VMAW   0770
C*                                                                     *VMAW   0780
C***********************************************************************VMAW   0790
C                                                                       VMAW   0800
C                                                                       VMAW   0810
      DO 101 I=1,10                                                     VMAW   0820
101   STMODE(I,J)=STAW(I,K(J))                                          VMAW   0830
C                                                                       VMAW   0840
C                                                                       VMAW   0850
C***********************************************************************VMAW   0860
C*                                                                     *VMAW   0870
C*                      CALCULATE TANK VOLUME/MASS                     *VMAW   0880
C*                                                                     *VMAW   0890
C***********************************************************************VMAW   0900
C                                                                       VMAW   0910
C                                                                       VMAW   0920
      GO TO (102,103,104,105),K(J)                                      VMAW   0930
C                                                                       VMAW   0940
C                                                                       VMAW   0950
C***********************************************************************VMAW   0960
C*                                                                     *VMAW   0970
C*                         GAS STORAGE (300 K)                         *VMAW   0980
C*                                                                     *VMAW   0990
C***********************************************************************VMAW   1000
C                                                                       VMAW   1010
C                                                                       VMAW   1020
102   MTANK=MTANK+3.26960*MN2                                           VMAW   1030
     -            +0.284938*MN2**(2.0/3.0)                              VMAW   1040
     -            +30.8400*MN2/RTIME                                    VMAW   1050
      VTANK=VTANK+3.32512E-03*MN2                                       VMAW   1060
     -            +1.45542E-02*MN2/RTIME                                VMAW   1070
      RETURN                                                            VMAW   1080
103   MTANK=MTANK+3.90631*MN2                                           VMAW   1090
     -            +0.629548*MN2**(2.0/3.0)                              VMAW   1100
     -            +30.8400*MN2/RTIME                                    VMAW   1110
      VTANK=VTANK+3.32512E-03*MN2                                       VMAW   1120
     -            +1.45542E-02*MN2/RTIME                                VMAW   1130
      RETURN                                                            VMAW   1140
C                                                                       VMAW   1150
C                                                                       VMAW   1160
C***********************************************************************VMAW   1170
C*                                                                     *VMAW   1180
C*                    HPS LIQUID STORAGE (77.5 K)                      *VMAW   1190
```

```
C*                                                                     *
C***********************************************************************
C
C
104   MVT=1.22861*MN2
     -    +0.882613*MN2**(2.0/3.0)
     -    +0.127222*MN2**(1.0/3.0)
     -    +50.6600*MN2/RTIME
      MMT=1.19593*MN2
     -    +1.13820*MN2**(2.0/3.0)
     -    +0.127222*MN2**(1.0/3.0)
     -    +50.6600*MN2/RTIME
      MTANK=MTANK+AMAX1(MVT,MMT)
      VTANK=VTANK+1.49639E-03*MN2
     -               +9.95326E-04*MN2**(2.0/3.0)
     -               +2.20679E-04*MN2**(1.0/3.0)
     -               +3.16948E-02*MN2/RTIME
      RETURN
105   MVT=1.20968*MN2
     -    +1.99684*MN2**(2.0/3.0)
     -    +2.07277*MN2**(1.0/3.0)
     -    +50.6600*MN2/RTIME
      MMT=1.17700*MN2
     -    +2.25223*MN2**(2.0/3.0)
     -    +2.07277*MN2**(1.0/3.0)
     -    +50.6600*MN2/RTIME
      MTANK=MTANK+AMAX1(MVT,MMT)
      VTANK=VTANK+1.49639E-03*MN2
     -               +4.97663E-03*MN2**(2.0/3.0)
     -               +5.51700E-03*MN2**(1.0/3.0)
     -               +3.16948E-02*MN2/RTIME
      END
```

```
      SUBROUTINE VMCS(J,MH2O,RTIME,MCS,VCS)
C
C
C***********************************************************************
C*
C*                COOLING SYSTEM VOLUME/MASS SUBROUTINE (VMCS)
C*
C***********************************************************************
C
C***********************************************************************
C*
C*  SUBROUTINE VMCS CALCULATES THE VOLUME/MASS FOR THE COOLING SYSTEM
C*  INCLUDING HARDWARE AND H2O STORAGE TANK.
C*
C*  H2O FOR THE COOLING SYSTEM MAY BE STORED ANY OF FIVE WAYS:
C*
C*    K        1             2             3             4
C*    PHASE    LIQ           LIQ           LIQ           LIQ
C*    CONT     SPH           CYL           SPH           CYL
C*    STEMP    300.0 K       300.0 K       300.0 K       300.0 K
C*    STIME    INFINITE      INFINITE      INFINITE      INFINITE
C*    SPRES    2.8E+06 PA    2.8E+06 PA    1 ATM         1 ATM
C*             (400 PSI)     (400 PSI)
C*    RFSYS    PGS           PGS           PFS           PFS
C*    MATER    TI            TI            AL            AL
C*
C*    K        5
C*    PHASE    LIQ
C*    CONT     SPH
C*    STEMP    368-388 K
C*    STIME    INFINITE
C*    SPRES    1 ATM
C*    RFSYS    RFP
C*    MATER    AL
C*
C*  INPUT VARIABLES:
C*
C*  J      = STORAGE MODE CONTROL VARIABLE
C*  K      = STORAGE MODE CONTROL ARRAY
C*  MH2O   = TOTAL DELIVERED MASS OF H2O (KG)
C*  RTIME  = RUN TIME (S)
C*
C*  OUTPUT VARIABLES:
C*
C*  MCS    = COOLING SYSTEM MASS (KG)
C*  STCS   = STORAGE MODE DESCRIPTOR DATA ARRAY
C*  STMODE = STORAGE MODE DESCRIPTOR ARRAY
C*  VCS    = COOLING SYSTEM VOLUME (M3)
C*
C***********************************************************************
C
C
      IMPLICIT REAL(M)
C
      COMMON/SCS4/K(10)
```

```
C                                                                       VMCS   0650
      COMMON/SCS5/STMODE(10,10)                                         VMCS   0660
C                                                                       VMCS   0670
      COMMON/SCS7/STCS(10,5)                                            VMCS   0680
C                                                                       VMCS   0690
      DATA ((STCS(I,K),K=1,4),I=1,10)/                                  VMCS   0700
     -10HH20-CS    ,10HH20-CS    ,10HH20-CS    ,10HH20-CS    ,          VMCS   0710
     -10HLIQ       ,10HLIQ       ,10HLIQ       ,10HLIQ       ,          VMCS   0720
     -10HSPH       ,10HCYL       ,10HSPH       ,10HCYL       ,          VMCS   0730
     -10H300.0 K   ,10H300.0 K   ,10H300.0 K   ,10H300.0 K   ,          VMCS   0740
     -10HINFINITE  ,10HINFINITE  ,10HINFINITE  ,10HINFINITE  ,          VMCS   0750
     -10H          ,10H          ,10H          ,10H          ,          VMCS   0760
     -10H2.8E+06 PA,10H2.8E+06 PA,10H1 ATM     ,10H1 ATM     ,          VMCS   0770
     -10H(400 PSI) ,10H(400 PSI) ,10H          ,10H          ,          VMCS   0780
     -10HPGS       ,10HPGS       ,10HPFS       ,10HPFS       ,          VMCS   0790
     -10HTI        ,10HTI        ,10HAL        ,10HAL        /          VMCS   0800
      DATA (STCS(I,5),I=1,10)/                                          VMCS   0810
     -10HH20-CS    ,                                                    VMCS   0820
     -10HLIQ       ,                                                    VMCS   0830
     -10HSPH       ,                                                    VMCS   0840
     -10H368-388 K ,                                                    VMCS   0850
     -10HINFINITE  ,                                                    VMCS   0860
     -10H          ,                                                    VMCS   0870
     -10H1 ATM     ,                                                    VMCS   0880
     -10H          ,                                                    VMCS   0890
     -10HRFP       ,                                                    VMCS   0900
     -10HAL        /                                                    VMCS   0910
C                                                                       VMCS   0920
C                                                                       VMCS   0930
C***********************************************************************VMCS   0940
C*                                                                     *VMCS   0950
C*                  SET STORAGE MODE DESCRIPTOR ARRAY                  *VMCS   0960
C*                                                                     *VMCS   0970
C***********************************************************************VMCS   0980
C                                                                       VMCS   0990
C                                                                       VMCS   1000
      DO 101 I=1,10                                                     VMCS   1010
101   STMODE(I,J)=STCS(I,K(J))                                          VMCS   1020
C                                                                       VMCS   1030
C                                                                       VMCS   1040
C***********************************************************************VMCS   1050
C*                                                                     *VMCS   1060
C*                 CALCULATE COOLING SYSTEM VOLUME/MASS                *VMCS   1070
C*                                                                     *VMCS   1080
C***********************************************************************VMCS   1090
C                                                                       VMCS   1100
C                                                                       VMCS   1110
      GO TO (102,103,104,105,106),K(J)                                  VMCS   1120
C                                                                       VMCS   1130
C                                                                       VMCS   1140
C***********************************************************************VMCS   1150
C*                                                                     *VMCS   1160
C*                      PGS LIQUID STORAGE (300.0 K)                   *VMCS   1170
C*                                                                     *VMCS   1180
C***********************************************************************VMCS   1190
```

```
C
C
102   MVT=1.31266*MH2O
     -   +0.144270*MH2O**(2.0/3.0)
      MMT=1.26582*MH2O
     -   +0.268637*MH2O**(2.0/3.0)
      MCS=AMAX1(MVT,MMT)
      VCS=1.34760E-03*MH2O
      RETURN
103   MVT=1.30600*MH2O
     -   +0.278415*MH2O**(2.0/3.0)
      MMT=1.24362*MH2O
     -   +0.553176*MH2O**(2.0/3.0)
      MCS=AMAX1(MVT,MMT)
      VCS=1.34760E-03*MH2O
      RETURN
C
C
C***********************************************************************
C*                                                                     *
C*                      PFS LIQUID STORAGE (300.0 K)                   *
C*                                                                     *
C***********************************************************************
C
C
104   MCS=1.19153*MH2O
     -   +0.346386*MH2O**(2.0/3.0)
     -   +3.62274*(MH2O/RTIME)**(2.0/3.0)
     -   +2.08062*(MH2O/RTIME)**(1.0/3.0)
      VCS=1.22931E-03*MH2O
     -   +2.28810E-03*(MH2O/RTIME)**(2.0/3.0)
     -   +1.31411E-03*(MH2O/RTIME)**(1.0/3.0)
      RETURN
105   MCS=1.16953*MH2O
     -   +0.765310*MH2O**(2.0/3.0)
     -   +3.62274*(MH2O/RTIME)**(2.0/3.0)
     -   +2.08062*(MH2O/RTIME)**(1.0/3.0)
      VCS=1.22931E-03*MH2O
     -   +2.28810E-03*(MH2O/RTIME)**(2.0/3.0)
     -   +1.31411E-03*(MH2O/RTIME)**(1.0/3.0)
      RETURN
C
C
C***********************************************************************
C*                                                                     *
C*                   RFP LIQUID STORAGE (368-388 K)                    *
C*                                                                     *
C***********************************************************************
C
C
106   MCS=46.0
     -   +2.06716E-02*MH2O
     -   +22.3800*MH2O/RTIME
     -   +26.3317*(MH2O/RTIME)**(2.0/3.0)
     -   +2.49379*(MH2O/RTIME)**(1.0/3.0)
```

```
                                                                      VMCS    1750
      VCS=4.50098E-02                                                 VMCS    1760
     -    +2.11566E-05*MH2O                                           VMCS    1770
     -    +2.34458E-02*MH2O/RTIME                                     VMCS    1780
     -    +2.87723E-02*(MH2O/RTIME)**(2.0/3.0)                        VMCS    1790
     -    +1.57507E-03*(MH2O/RTIME)**(1.0/3.0)                        VMCS    1800
      RETURN                                                          VMCS    1810
      END
```

```
      SUBROUTINE VMC2H4(J,MC2H4,P0,MTANK,VTANK)
C
C
C***********************************************************************
C*                                                                     *
C*               C2H4 TANK VOLUME/MASS SUBROUTINE (VMC2H4)             *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C*  SUBROUTINE VMC2H4 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE  *
C*  OF C2H4.                                                           *
C*                                                                     *
C*  C2H4 MAY BE STORED ANY OF TWO WAYS:                                *
C*                                                                     *
C*     K        1              2                                       *
C*     PHASE    GAS            GAS                                     *
C*     CONT     SPH            CYL                                     *
C*     STEMP    300.0 K        300.0 K                                 *
C*     STIME    INFINITE       INFINITE                                *
C*     SPRES    4.1E+07 PA     4.1E+07 PA                              *
C*              (6000 PSI)     (6000 PSI)                              *
C*     RFSYS    BLD            BLD                                     *
C*     MATER    TI             TI                                      *
C*                                                                     *
C*  INPUT VARIABLES:                                                   *
C*                                                                     *
C*  J      = STORAGE MODE CONTROL VARIABLE                             *
C*  K      = STORAGE MODE CONTROL ARRAY                                *
C*  MC2H4  = TOTAL DELIVERED MASS OF C2H4 (KG)                         *
C*  P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)              *
C*                                                                     *
C*  OUTPUT VARIABLES:                                                  *
C*                                                                     *
C*  MTANK  = TANK MASS (KG)                                            *
C*  STC2H4 = STORAGE MODE DESCRIPTOR DATA ARRAY                        *
C*  STMODE = STORAGE MODE DESCRIPTOR ARRAY                             *
C*  VTANK  = TANK VOLUME (M3)                                          *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
C
      COMMON/SCS4/K(10)
C
      COMMON/SCS5/STMODE(10,10)
C
      COMMON/SCS8/STC2H4(10,2)
C
      DATA ((STC2H4(I,K),K=1,2),I=1,10)/
     -10HC2H4      ,10HC2H4      ,
     -10HGAS       ,10HGAS       ,
     -10HSPH       ,10HCYL       ,
```

```
     -10H300.0 K   ,10H300.0 K   ,
     -10HINFINITE  ,10HINFINITE  ,
     -10H          ,10H          ,
     -10H4.1E+07 PA,10H4.1E+07 PA,
     -10H(6000 PSI),10H(6000 PSI),
     -10HBLD       ,10HBLD       ,
     -10HTI        ,10HTI        /
C
C
C***********************************************************************
C*                                                                     *
C*                  SET STORAGE MODE DESCRIPTOR ARRAY                  *
C*                                                                     *
C***********************************************************************
C
C
      DO 101 I=1,10
101   STMODE(I,J)=STC2H4(I,K(J))
C
C
C***********************************************************************
C*                                                                     *
C*                      CALCULATE TANK VOLUME/MASS                     *
C*                                                                     *
C***********************************************************************
C
C
      AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.23910))
      GO TO (102,103),K(J)
102   MTANK=MTANK+2.46738*AF*MC2H4
     -             +0.219165*(AF*MC2H4)**(2.0/3.0)
      VTANK=VTANK+2.24304E-03*AF*MC2H4
      RETURN
103   MTANK=MTANK+2.89199*AF*MC2H4
     -             +0.484226*(AF*MC2H4)**(2.0/3.0)
      VTANK=VTANK+2.24304E-03*AF*MC2H4
      END
```

```
      SUBROUTINE VMD2(J,MD2,P0,MTANK,VTANK)
C
C
C***********************************************************************
C*                                                                     *
C*                  D2 TANK VOLUME/MASS SUBROUTINE (VMD2)              *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C*   SUBROUTINE VMD2 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE   *
C*   OF D2.                                                            *
C*                                                                     *
C*  D2 MAY BE STORED ANY OF FOUR WAYS:                                 *
C*                                                                     *
C*    K        1             2             3             4             *
C*    PHASE    GAS           GAS           GAS           GAS           *
C*    CONT     SPH           CYL           SPH           SPH           *
C*    STEMP    300.0 K       300.0 K       77.5 K        77.5 K        *
C*    STIME    INFINITE      INFINITE      8.6E+05 S     1.6E+07 S     *
C*                                         (10 DAY)      (180 DAY)     *
C*    SPRES    4.1E+07 PA    4.1E+07 PA    4.1E+07 PA    4.1E+07 PA    *
C*             (6000 PSI)    (6000 PSI)    (6000 PSI)    (6000 PSI)    *
C*    RFSYS    BLD           BLD           BLD           BLD           *
C*    MATER    TI            TI            SS            SS            *
C*                                                                     *
C*  INPUT VARIABLES:                                                   *
C*                                                                     *
C*  J       = STORAGE MODE CONTROL VARIABLE                            *
C*  K       = STORAGE MODE CONTROL ARRAY                               *
C*  MD2     = TOTAL DELIVERED MASS OF D2 (KG)                          *
C*  P0      = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)             *
C*                                                                     *
C*  OUTPUT VARIABLES:                                                  *
C*                                                                     *
C*  MTANK  = TANK MASS (KG)                                            *
C*  STD2   = STORAGE MODE DESCRIPTOR DATA ARRAY                        *
C*  STMODE = STORAGE MODE DESCRIPTOR ARRAY                             *
C*  VTANK  = TANK VOLUME (M3)                                          *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
C
      COMMON/SCS4/K(10)
C
      COMMON/SCS5/STMODE(10,10)
C
      COMMON/SCS9/STD2(10,4)
C
      DATA ((STD2(I,K),K=1,4),I=1,10)/
     -10HD2          ,10HD2          ,10HD2         ,10HD2         ,
     -10HGAS         ,10HGAS         ,10HGAS        ,10HGAS        ,
```

```
     -10HSPH      ,10HCYL      ,10HSPH      ,10HSPH      ,              VMD2    0650
     -10H300.0 K  ,10H300.0 K  ,10H77.5 K   ,10H77.5 K   ,              VMD2    0660
     -10HINFINITE ,10HINFINITE ,10H8.6E+05 S ,10H1.6E+07 S ,              VMD2    0670
     -10H         ,10H         ,10H(10 DAY)  ,10H(180 DAY) ,              VMD2    0680
     -10H4.1E+07 PA,10H4.1E+07 PA,10H4.1E+07 PA,10H4.1E+07 PA,          VMD2    0690
     -10H(6000 PSI),10H(6000 PSI),10H(6000 PSI),10H(6000 PSI),          VMD2    0700
     -10HBLD      ,10HBLD      ,10HBLD      ,10HBLD      ,              VMD2    0710
     -10HTI       ,10HTI       ,10HSS       ,10HSS       /              VMD2    0720
C                                                                       VMD2    0730
C                                                                       VMD2    0740
C***********************************************************************VMD2    0750
C*                                                                     *VMD2    0760
C*                 SET STORAGE MODE DESCRIPTOR ARRAY                   *VMD2    0770
C*                                                                     *VMD2    0780
C***********************************************************************VMD2    0790
C                                                                       VMD2    0800
C                                                                       VMD2    0810
      DO 101 I=1,10                                                     VMD2    0820
101   STMODE(I,J)=STO2(I,K(J))                                          VMD2    0830
C                                                                       VMD2    0840
C                                                                       VMD2    0850
C***********************************************************************VMD2    0860
C*                                                                     *VMD2    0870
C*                     CALCULATE TANK VOLUME/MASS                      *VMD2    0880
C*                                                                     *VMD2    0890
C***********************************************************************VMD2    0900
C                                                                       VMD2    0910
C                                                                       VMD2    0920
      GO TO (102,102,105,105),K(J)                                      VMD2    0930
C                                                                       VMD2    0940
C                                                                       VMD2    0950
C***********************************************************************VMD2    0960
C*                                                                     *VMD2    0970
C*                       GAS STORAGE (300 K)                           *VMD2    0980
C*                                                                     *VMD2    0990
C***********************************************************************VMD2    1000
C                                                                       VMD2    1010
C                                                                       VMD2    1020
102   AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.39822))                      VMD2    1030
      GO TO (103,104),K(J)                                              VMD2    1040
103   MTANK=MTANK+13.4155*AF*MD2                                        VMD2    1050
     -                +0.349597*(AF*MD2)**(2.0/3.0)                     VMD2    1060
      VTANK=VTANK+2.02297E-02*AF*MD2                                    VMD2    1070
      RETURN                                                            VMD2    1080
104   MTANK=MTANK+17.4102*AF*MD2                                        VMD2    1090
     -                +2.09806*(AF*MD2)**(2.0/3.0)                      VMD2    1100
      VTANK=VTANK+2.02297E-02*AF*MD2                                    VMD2    1110
      RETURN                                                            VMD2    1120
C                                                                       VMD2    1130
C                                                                       VMD2    1140
C***********************************************************************VMD2    1150
C*                                                                     *VMD2    1160
C*                       GAS STORAGE (77.5 K)                          *VMD2    1170
C*                                                                     *VMD2    1180
C***********************************************************************VMD2    1190
```

```
C                                                                 VWD2   1200
C                                                                 VWD2   1210
105   AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.37800))                VWD2   1220
      GO TO (106,107),K(J)-2                                      VWD2   1230
106   WTANK=WTANK+4.46776*AF*WD2                                  VWD2   1240
     -             +2.53708*(AF*WD2)**(2.0/3.0)                   VWD2   1250
      VTANK=VTANK+6.56745E-03*AF*WD2                              VWD2   1260
     -             +2.62703E-03*(AF*WD2)**(2.0/3.0)               VWD2   1270
     -             +3.50275E-04*(AF*WD2)**(1.0/3.0)               VWD2   1280
      RETURN                                                      VWD2   1290
107   WTANK=WTANK+4.38071*AF*WD2                                  VWD2   1300
     -             +5.61743*(AF*WD2)**(2.0/3.0)                   VWD2   1310
     -             +3.44660*(AF*WD2)**(1.0/3.0)                   VWD2   1320
      VTANK=VTANK+6.56745E-03*AF*WD2                              VWD2   1330
     -             +1.31352E-02*(AF*WD2)**(2.0/3.0)               VWD2   1340
     -             +8.75692E-03*(AF*WD2)**(1.0/3.0)               VWD2   1350
      END                                                         VWD2   1360
```

```
      SUBROUTINE VMF2(J,MF2,MHE,P0,MTANK,VTANK)                         VMF2   0100
C                                                                       VMF2   0110
C                                                                       VMF2   0120
C***********************************************************************VMF2   0130
C*                                                                     *VMF2   0140
C*                  F2 TANK VOLUME/MASS SUBROUTINE (VMF2)              *VMF2   0150
C*                                                                     *VMF2   0160
C***********************************************************************VMF2   0170
C                                                                       VMF2   0180
C***********************************************************************VMF2   0190
C*                                                                     *VMF2   0200
C*   SUBROUTINE VMF2 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE   *VMF2   0210
C*   OF F2.                                                            *VMF2   0220
C*                                                                     *VMF2   0230
C*  F2  MAY BE STORED ANY OF FOUR WAYS: HOWEVER, WHEN STORED AS A GAS, *VMF2   0240
C*  F2  IS  STORED WITH  HE AS  A GAS  MIXTURE AT A  PARTIAL  PRESSURE *VMF2   0250
C*  PF2 = 6.89476E+06 PA  (1000 PSIA)  PROVIDED  HE IS  PRESENT IN THE *VMF2   0260
C*  SYSTEM:                                                            *VMF2   0270
C*                                                                     *VMF2   0280
C*    K          1               2               3              4      *VMF2   0290
C*    PHASE      GAS             GAS             LIQ            LIQ    *VMF2   0300
C*    CONT       SPH             CYL             SPH            SPH    *VMF2   0310
C*    STEMP      300.0 K         300.0 K         77.5 K         77.5 K *VMF2   0320
C*    STIME      INFINITE        INFINITE        8.6E+05 S      1.6E+07 S *VMF2   0330
C*                                               (10 DAY)       (180 DAY) *VMF2   0340
C*    SPRES      6.9E+06 PA      6.9E+06 PA      1.25*P0        1.25*P0*VMF2   0350
C*               (1000 PSI)      (1000 PSI)                            *VMF2   0360
C*    RESYS      BLD             BLD             PGS            PGS    *VMF2   0370
C*    MATER      SS              SS              SS             SS     *VMF2   0380
C*                                                                     *VMF2   0390
C*  INPUT VARIABLES:                                                   *VMF2   0400
C*                                                                     *VMF2   0410
C*  J       = STORAGE MODE CONTROL VARIABLE                            *VMF2   0420
C*  K       = STORAGE MODE CONTROL ARRAY                               *VMF2   0430
C*  MF2     = TOTAL DELIVERED MASS OF F2 (KG)                          *VMF2   0440
C*  MHE     = TOTAL DELIVERED MASS OF HE (KG)                          *VMF2   0450
C*  P0      = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)             *VMF2   0460
C*                                                                     *VMF2   0470
C*  OUTPUT VARIABLES:                                                  *VMF2   0480
C*                                                                     *VMF2   0490
C*  MTANK   = TANK MASS (KG)                                           *VMF2   0500
C*  STF2    = STORAGE MODE DESCRIPTOR DATA ARRAY                       *VMF2   0510
C*  STMODE  = STORAGE MODE DESCRIPTOR ARRAY                            *VMF2   0520
C*  VTANK   = TANK VOLUME (M3)                                         *VMF2   0530
C*                                                                     *VMF2   0540
C***********************************************************************VMF2   0550
C                                                                       VMF2   0560
C                                                                       VMF2   0570
      IMPLICIT REAL(M)                                                  VMF2   0580
C                                                                       VMF2   0590
      COMMON/SCS4/K(10)                                                 VMF2   0600
C                                                                       VMF2   0610
      COMMON/SCS5/STMODE(10,10)                                         VMF2   0620
C                                                                       VMF2   0630
      COMMON/SCS10/STF2(10,4)                                           VMF2   0640
```

```
C                                                                       VMF2   0650
      DATA ((STF2(I,K),K=1,4),I=1,10)/                                  VMF2   0660
     -10HF2          ,10HF2          ,10HF2          ,10HF2          ,  VMF2   0670
     -10HGAS         ,10HGAS         ,10HLIQ         ,10HLIQ         ,  VMF2   0680
     -10HSPH         ,10HCYL         ,10HSPH         ,10HSPH         ,  VMF2   0690
     -10H300.0 K     ,10H300.0 K     ,10H77.5 K      ,10H77.5 K      ,  VMF2   0700
     -10HINFINITE    ,10HINFINITE    ,10H8.6E+05 S   ,10H1.6E+07 S   ,  VMF2   0710
     -10H            ,10H            ,10H(10 DAY)    ,10H(180 DAY)   ,  VMF2   0720
     -10H6.9E+06 PA,10H6.9E+06 PA,10H1.25*P0     ,10H1.25*P0     ,      VMF2   0730
     -10H(1000 PSI),10H(1000 PSI),10H            ,10H            ,      VMF2   0740
     -10HBLD         ,10HBLD         ,10HPGS         ,10HPGS         ,  VMF2   0750
     -10HSS          ,10HSS          ,10HSS          ,10HSS          /  VMF2   0760
C                                                                       VMF2   0770
C                                                                       VMF2   0780
C***********************************************************************VMF2   0790
C*                                                                     *VMF2   0800
C*                     SET STORAGE MODE DESCRIPTOR ARRAY               *VMF2   0810
C*                                                                     *VMF2   0820
C***********************************************************************VMF2   0830
C                                                                       VMF2   0840
C                                                                       VMF2   0850
      DO 101 I=1,10                                                     VMF2   0860
101   STMODE(I,J)=STF2(I,K(J))                                          VMF2   0870
C                                                                       VMF2   0880
C                                                                       VMF2   0890
C***********************************************************************VMF2   0900
C*                                                                     *VMF2   0910
C*                           CALCULATE TANK VOLUME/MASS                *VMF2   0920
C*                                                                     *VMF2   0930
C***********************************************************************VMF2   0940
C                                                                       VMF2   0950
C                                                                       VMF2   0960
      GO TO (102,102,105,105),K(J)                                      VMF2   0970
C                                                                       VMF2   0980
C                                                                       VMF2   0990
C***********************************************************************VMF2   1000
C*                                                                     *VMF2   1010
C*                              GAS STORAGE (300 K)                    *VMF2   1020
C*                                                                     *VMF2   1030
C***********************************************************************VMF2   1040
C                                                                       VMF2   1050
C                                                                       VMF2   1060
102   IF(MHE.NE.0.0) STMODE(1,J)=10HF2/HE                               VMF2   1070
      XFF2=1.0/(1.0+(37.9968*MHE)/(4.0026*MF2))                         VMF2   1080
      XFHE=1.0-XFF2                                                     VMF2   1090
      PS=6.89476E+06/XFF2                                               VMF2   1100
      PHE=PS-6.89476E+06                                                VMF2   1110
      MW=37.9968*(MHE/MF2+1.0)/(XFHE/XFF2+1.0)                          VMF2   1120
      G=(2.50092*XFHE/XFF2+4.16146)/(1.50092*XFHE/XFF2+3.16146)         VMF2   1130
      ZHE=4.61576E-09*PHE+1.00053                                       VMF2   1140
      Z=0.980555*XFF2+ZHE*XFHE                                          VMF2   1150
      AF=1.0/(1.0-(1.25*P0/PS)**(1.0/G))                                VMF2   1160
      MTOTAL=MHE+MF2                                                    VMF2   1170
      IF(PS.GT.4.13685E+07) WRITE(6,201)(PS,II=1,9)                     VMF2   1180
      GO TO(103,104),K(J)                                               VMF2   1190
```

```
103   MTANK=MTANK+1.10210*(1.0+67.5353*Z/MW)*AF*MTOTAL
     -          +2.47854E+05*(Z*AF*MTOTAL/(PS*MW))**(2.0/3.0)
      VTANK=VTANK+2.69759E+06*Z*AF*MTOTAL/(PS*MW)
      RETURN
104   MTANK=MTANK+1.08150*(1.0+91.2639*Z/MW)*AF*MTOTAL
     -          +5.47613E+05*(Z*AF*MTOTAL/(PS*MW))**(2.0/3.0)
      VTANK=VTANK+2.69759E+06*Z*AF*MTOTAL/(PS*MW)
      RETURN
C
C
C***********************************************************************
C*                                                                     *
C*                      PGS LIQUID STORAGE (77.5 K)                    *
C*                                                                     *
C***********************************************************************
C
C
105   AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.61019))
      Z=1.74986E-08*1.25*P0+0.999271
      MPGS=7.08056E-03*MF2/(1.22656E+05*Z/P0-6.76795E-03*AF)
      GO TO (106,107),K(J)-2
106   MTTPGS=4.71181*AF*MPGS
     -      +2.67404*(AF*MPGS)**(2.0/3.0)
     -      +0.217186*(AF*MPGS)**(1.0/3.0)
      VTTPGS=7.10635E-03*AF*MPGS
     -      +2.76884E-03*(AF*MPGS)**(2.0/3.0)
     -      +3.59605E-04*(AF*MPGS)**(1.0/3.0)
      MVT=1.18685*MF2
     -   +1.68221E-08*P0*MF2
     -   +0.571231*MF2**(2.0/3.0)
     -   +0.102337*MF2**(1.0/3.0)
      MMT=1.18685*MF2
     -   +0.736480*MF2**(2.0/3.0)
     -   +0.102337*MF2**(1.0/3.0)
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS
      VTANK=VTANK+7.78861E-04*MF2
     -           +6.44034E-04*MF2**(2.0/3.0)
     -           +1.77514E-04*MF2**(1.0/3.0)
     -           +VTTPGS
      RETURN
107   MTTPGS=4.61764*AF*MPGS
     -      +5.92067*(AF*MPGS)**(2.0/3.0)
     -      +3.53850*(AF*MPGS)**(1.0/3.0)
      VTTPGS=7.10635E-03*AF*MPGS
     -      +1.38442E-02*(AF*MPGS)**(2.0/3.0)
     -      +8.99017E-03*(AF*MPGS)**(1.0/3.0)
      MVT=1.17700*MF2
     -   +1.68221E-08*P0*MF2
     -   +1.29207*MF2**(2.0/3.0)
     -   +1.66733*MF2**(1.0/3.0)
      MMT=1.17700*MF2
     -   +1.45732*MF2**(2.0/3.0)
     -   +1.66733*MF2**(1.0/3.0)
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS
      VTANK=VTANK+7.78861E-04*MF2
```

```
     -         +3.22017E-03*MF2**(2.0/3.0)                              VMF2    1750
     -         +4.43787E-03*MF2**(1.0/3.0)                              VMF2    1760
     -         +VTTPOS                                                  VMF2    1770
      RETURN                                                            VMF2    1780
C                                                                       VMF2    1790
C                                                                       VMF2    1800
C***********************************************************************VMF2    1810
C*                                                                     *VMF2    1820
C*                      FORMAT STATEMENTS                              *VMF2    1830
C*                                                                     *VMF2    1840
C***********************************************************************VMF2    1850
C                                                                       VMF2    1860
C                                                                       VMF2    1870
201   FORMAT(*1*,T2,*WARNING: STORAGE PRESSURE FOR F2/HE EXCEEDS 4.13685VMF2    1880
     -E+07 PA (6000 PSIA)*,9(/,T2,*PS =*,E13.6,* PA*))                  VMF2    1890
      END                                                               VMF2    1900
```

```
      SUBROUTINE VMHE(J,MHE,P0,MTANK,VTANK)                             VMHE    0100
C                                                                       VMHE    0110
C                                                                       VMHE    0120
C***********************************************************************VMHE    0130
C*                                                                     *VMHE    0140
C*                 HE TANK VOLUME/MASS SUBROUTINE (VMHE)               *VMHE    0150
C*                                                                     *VMHE    0160
C***********************************************************************VMHE    0170
C                                                                       VMHE    0180
C***********************************************************************VMHE    0190
C*                                                                     *VMHE    0200
C*    SUBROUTINE VMHE CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE  *VMHE    0210
C*    OF HE.                                                           *VMHE    0220
C*                                                                     *VMHE    0230
C*   HE MAY BE STORED ANY OF FOUR WAYS:                                *VMHE    0240
C*                                                                     *VMHE    0250
C*     K        1             2             3             4            *VMHE    0260
C*     PHASE    GAS           GAS           GAS           GAS          *VMHE    0270
C*     CONT     SPH           CYL           SPH           SPH          *VMHE    0280
C*     STEMP    300.0 K       300.0 K       77.5 K        77.5 K       *VMHE    0290
C*     STIME    INFINITE      INFINITE      8.6E+05 S     1.6E+07 S    *VMHE    0300
C*                                          (10 DAY)      (180 DAY)    *VMHE    0310
C*     SPRES    4.1E+07 PA    4.1E+07 PA    4.1E+07 PA    4.1E+07 PA   *VMHE    0320
C*              (6000 PSI)    (6000 PSI)    (6000 PSI)    (6000 PSI)   *VMHE    0330
C*     RFSYS    BLD           BLD           BLD           BLD          *VMHE    0340
C*     MATER    TI            TI            SS            SS           *VMHE    0350
C*                                                                     *VMHE    0360
C*   INPUT VARIABLES:                                                  *VMHE    0370
C*                                                                     *VMHE    0380
C*   J       = STORAGE MODE CONTROL VARIABLE                           *VMHE    0390
C*   K       = STORAGE MODE CONTROL ARRAY                              *VMHE    0400
C*   MHE     = TOTAL DELIVERED MASS OF HE (KG)                         *VMHE    0410
C*   P0      = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)            *VMHE    0420
C*                                                                     *VMHE    0430
C*   OUTPUT VARIABLES:                                                 *VMHE    0440
C*                                                                     *VMHE    0450
C*   MTANK   = TANK MASS (KG)                                          *VMHE    0460
C*   STHE    = STORAGE MODE DESCRIPTOR DATA ARRAY                      *VMHE    0470
C*   STMODE  = STORAGE MODE DESCRIPTOR ARRAY                           *VMHE    0480
C*   VTANK   = TANK VOLUME (M3)                                        *VMHE    0490
C*                                                                     *VMHE    0500
C***********************************************************************VMHE    0510
C                                                                       VMHE    0520
C                                                                       VMHE    0530
      IMPLICIT REAL(M)                                                  VMHE    0540
C                                                                       VMHE    0550
      COMMON/SCS4/K(10)                                                 VMHE    0560
C                                                                       VMHE    0570
      COMMON/SCS5/STMODE(10,10)                                         VMHE    0580
C                                                                       VMHE    0590
      COMMON/SCS11/STHE(10,4)                                           VMHE    0600
C                                                                       VMHE    0610
      DATA ((STHE(I,K),K=1,4),I=1,10)/                                  VMHE    0620
     -10HHE        ,10HHE        ,10HHE        ,10HHE        ,          VMHE    0630
     -10HGAS       ,10HGAS       ,10HGAS       ,10HGAS       ,          VMHE    0640
```

```
     -10HSEM      ,10HCYL      ,10HSPH      ,10HSPH      ,      VMHE
     -10H300.0 K  ,10H300.0 K  ,10H77.5 K   ,10H77.5 K   ,      VMHE
     -10HINFINITE ,10HINFINITE ,10H8.6E+05 S ,10H1.6E+07 S ,      VMHE
     -10H         ,10H         ,10H(10 DAY)  ,10H(180 DAY) ,      VMHE
     -10H4.1E+07 PA,10H4.1E+07 PA,10H4.1E+07 PA,10H4.1E+07 PA,      VMHE
     -10H(6000 PSI),10H(6000 PSI),10H(6000 PSI),10H(6000 PSI),      VMHE
     -10HBLD      ,10HBLD      ,10HBLD      ,10HBLD      ,      VMHE
     -10HTI       ,10HTI       ,10HSS       ,10HSS       /      VMHE
C                                                                 VMHE
C                                                                 VMHE
C*****************************************************************VMHE
C*                                                               *VMHE
C*                SET STORAGE MODE DESCRIPTOR ARRAY              *VMHE
C*                                                               *VMHE
C*****************************************************************VMHE
C                                                                 VMHE
C                                                                 VMHE
      DO 101 I=1,10                                               VMHE
101   STMODE(I,J)=STHE(I,K(J))                                    VMHE
C                                                                 VMHE
C                                                                 VMHE
C*****************************************************************VMHE
C*                                                               *VMHE
C*                   CALCULATE TANK VOLUME/MASS                  *VMHE
C*                                                               *VMHE
C*****************************************************************VMHE
C                                                                 VMHE
C                                                                 VMHE
      GO TO (102,102,105,105),K(J)                                VMHE
C                                                                 VMHE
C                                                                 VMHE
C*****************************************************************VMHE
C*                                                               *VMHE
C*                     GAS STORAGE (300 K)                       *VMHE
C*                                                               *VMHE
C*****************************************************************VMHE
C                                                                 VMHE
C                                                                 VMHE
102   AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.6649H))                VMHE
      GO TO (103,104),K(J)                                        VMHE
103   MTANK=MTANK+12.8950*AF*MHE                                  VMHE
     -            +0.922645*(AF*MHE)**(2.0/3.0)                   VMHE
      VTANK=VTANK+1.93746E-02*AF*MHE                              VMHE
      RETURN                                                      VMHE
104   MTANK=MTANK+16.7199*AF*MHE                                  VMHE
     -            +2.03851*(AF*MHE)**(2.0/3.0)                    VMHE
      VTANK=VTANK+1.93746E-02*AF*MHE                              VMHE
      RETURN                                                      VMHE
C                                                                 VMHE
C                                                                 VMHE
C*****************************************************************VMHE
C*                                                               *VMHE
C*                     GAS STORAGE (77.5 K)                      *VMHE
C*                                                               *VMHE
C*****************************************************************VMHE
```

```
C                                                                 VMHE   1200
C                                                                 VMHE   1210
105   AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.61019))                VMHE   1220
      GO TO (106,107),K(J)-2                                      VMHE   1230
106   MTANK=MTANK+4.85317*AF*MHE                                  VMHE   1240
     -               +2.72725*(AF*MHE)**(2.0/3.0)                 VMHE   1250
     -               +0.219336*(AF*MHE)**(1.0/3.0)                VMHE   1260
      VTANK=VTANK+7.31954E-03*AF*MHE                              VMHE   1270
     -               +2.82395E-03*(AF*MHE)**(2.0/3.0)             VMHE   1280
     -               +3.63166E-04*(AF*MHE)**(1.0/3.0)             VMHE   1290
      RETURN                                                      VMHE   1300
107   MTANK=MTANK+4.75617*AF*MHE                                  VMHE   1310
     -               +6.03850*(AF*MHE)**(2.0/3.0)                 VMHE   1320
     -               +3.57353*(AF*MHE)**(1.0/3.0)                 VMHE   1330
      VTANK=VTANK+7.31954E-03*AF*MHE                              VMHE   1340
     -               +1.41197E-02*(AF*MHE)**(2.0/3.0)             VMHE   1350
     -               +9.07919E-03*(AF*MHE)**(1.0/3.0)             VMHE   1360
      END                                                         VMHE   1370
```

```
      SUBROUTINE VMH2(J,MH2,P0,MTANK,VTANK)
C
C
C***********************************************************************
C*                                                                     *
C*                 H2 TANK VOLUME/MASS SUBROUTINE (VMH2)               *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C*    SUBROUTINE VMH2 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE  *
C*    OF H2.                                                           *
C*                                                                     *
C*   H2 MAY BE STORED ANY OF FOUR WAYS:                                *
C*                                                                     *
C*     K          1               2               3               4    *
C*     PHASE      GAS             GAS             GAS             GAS  *
C*     CONT       SPH             CYL             SPH             SPH  *
C*     STEMP      300.0 K         300.0 K         77.5 K          77.5 K *
C*     STIME      INFINITE        INFINITE        8.6E+05 S       1.6E+07 S *
C*                                                (10 DAY)        (180 DAY) *
C*     SPRES      4.1E+07 PA      4.1E+07 PA      4.1E+07 PA      4.1E+07 PA *
C*                (6000 PSI)      (6000 PSI)      (6000 PSI)      (6000 PSI) *
C*     REFSYS     BLD             BLD             BLD             BLD  *
C*     MATER      TI              TI              SS              SS   *
C*                                                                     *
C*   INPUT VARIABLES:                                                  *
C*                                                                     *
C*   J        = STORAGE MODE CONTROL VARIABLE                          *
C*   K        = STORAGE MODE CONTROL ARRAY                             *
C*   MH2      = TOTAL DELIVERED MASS OF H2 [KG]                        *
C*   P0       = COMBUSTOR OR NOZZLE STAGNATION PRESSURE [PA]           *
C*                                                                     *
C*   OUTPUT VARIABLES:                                                 *
C*                                                                     *
C*   MTANK    = TANK MASS [KG]                                         *
C*   STH2     = STORAGE MODE DESCRIPTOR DATA ARRAY                     *
C*   STMODE   = STORAGE MODE DESCRIPTOR ARRAY                          *
C*   VTANK    = TANK VOLUME [M3]                                       *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
C
      COMMON/SCS4/K(10)
C
      COMMON/SCS5/STMODE(10,10)
C
      COMMON/SCS12/STH2(10,4)
C
      DATA ((STH2(I,K),K=1,4),I=1,10)/
     -10HH2         ,10HH2          ,10HH2         ,10HH2         ,
     -10HGAS        ,10HGAS         ,10HGAS        ,10HGAS        ,
```

```
     -10HSPH      ,10HCYL      ,10HSPH      ,10HSPH      ,                  VMH2    0650
     -10H300.0 K  ,10H300.0 K  ,10H77.5 K   ,10H77.5 K   ,                  VMH2    0660
     -10HINFINITE ,10HINFINITE ,10H8.6E+05 S ,10H1.6E+07 S ,                VMH2    0670
     -10H         ,10H         ,10H(10 DAY)  ,10H(180 DAY) ,                VMH2    0680
     -10H4.1E+07 PA,10H4.1E+07 PA,10H4.1E+07 PA,10H4.1E+07 PA,              VMH2    0690
     -10H(6000 PSI),10H(6000 PSI),10H(6000 PSI),10H(6000 PSI),              VMH2    0700
     -10HBLD      ,10HBLD      ,10HBLD      ,10HBLD      ,                  VMH2    0710
     -10HCSS      ,10HCSS      ,10HSS       ,10HSS       /                  VMH2    0720
C                                                                           VMH2    0730
C                                                                           VMH2    0740
C***********************************************************************VMH2    0750
C*                                                                     *VMH2    0760
C*                   SET STORAGE MODE DESCRIPTOR ARRAY                 *VMH2    0770
C*                                                                     *VMH2    0780
C***********************************************************************VMH2    0790
C                                                                       VMH2    0800
C                                                                       VMH2    0810
      DO 101 I=1,10                                                     VMH2    0820
101   STMODE(I,J)=STH2(I,K(J))                                          VMH2    0830
C                                                                       VMH2    0840
C                                                                       VMH2    0850
C***********************************************************************VMH2    0860
C*                                                                     *VMH2    0870
C*                        CALCULATE TANK VOLUME/MASS                   *VMH2    0880
C*                                                                     *VMH2    0890
C***********************************************************************VMH2    0900
C                                                                       VMH2    0910
C                                                                       VMH2    0920
      GO TO (102,102,105,105),K(J)                                      VMH2    0930
C                                                                       VMH2    0940
C                                                                       VMH2    0950
C***********************************************************************VMH2    0960
C*                                                                     *VMH2    0970
C*                          GAS STORAGE (300 K)                        *VMH2    0980
C*                                                                     *VMH2    0990
C***********************************************************************VMH2    1000
C                                                                       VMH2    1010
C                                                                       VMH2    1020
102   AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.36381))                      VMH2    1030
      GO TO (103,104),K(J)                                              VMH2    1040
103   MTANK=MTANK+25.9560*AF*MH2                                        VMH2    1050
     -               +1.51665*(AF*MH2)**(2.0/3.0)                       VMH2    1060
      VTANK=VTANK+4.08327E-02*AF*MH2                                    VMH2    1070
      RETURN                                                            VMH2    1080
104   MTANK=MTANK+34.0401*AF*MH2                                        VMH2    1090
     -               +3.35091*(AF*MH2)**(2.0/3.0)                       VMH2    1100
      VTANK=VTANK+4.08327E-02*AF*MH2                                    VMH2    1110
      RETURN                                                            VMH2    1120
C                                                                       VMH2    1130
C                                                                       VMH2    1140
C***********************************************************************VMH2    1150
C*                                                                     *VMH2    1160
C*                          GAS STORAGE (77.5 K)                       *VMH2    1170
C*                                                                     *VMH2    1180
C***********************************************************************VMH2    1190
```

```
C
C
105   AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.4466)))
      GO TO (106,107),K(J)-2
106   MTANK=MTANK+7.76831*AF*MH2
     -               +3.99336*(AF*MH2)**(2.0/3.0)
     -               +0.265409*(AF*MH2)**(1.0/3.0)
      VTANK=VTANK+1.29689E-02*AF*MH2
     -               +4.13494E-03*(AF*MH2)**(2.0/3.0)
     -               +4.39452E-04*(AF*MH2)**(1.0/3.0)
      RETURN
107   MTANK=MTANK+7.57645*AF*MH2
     -               +8.84183*(AF*MH2)**(2.0/3.0)
     -               +4.32419*(AF*MH2)**(1.0/3.0)
      VTANK=VTANK+1.29689E-02*AF*MH2
     -               +2.06747E-02*(AF*MH2)**(2.0/3.0)
     -               +1.09864E-02*(AF*MH2)**(1.0/3.0)
      END
```

```
      SUBROUTINE VMIRFNA(J,MIRFNA,P0,RTIME,MTANK,VTANK)                 VMIRFNA0100
C                                                                       VMIRFNA0110
C                                                                       VMIRFNA0120
C***********************************************************************VMIRFNA0130
C*                                                                     *VMIRFNA0140
C*               IRFNA TANK VOLUME/MASS SUBROUTINE (VMIRFNA)           *VMIRFNA0150
C*                                                                     *VMIRFNA0160
C***********************************************************************VMIRFNA0170
C                                                                       VMIRFNA0180
C***********************************************************************VMIRFNA0190
C*                                                                     *VMIRFNA0200
C* SUBROUTINE VMIRFNA CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE  *VMIRFNA0210
C* OF INHIBITED RED FUMING NITRIC ACID  (H1.4803N1.643504.631AF0.03).  *VMIRFNA0220
C*                                                                     *VMIRFNA0230
C*  IRFNA MAY BE STORED ANY OF FOUR WAYS:                              *VMIRFNA0240
C*                                                                     *VMIRFNA0250
C*    K        1             2             3             4             *VMIRFNA0260
C*    PHASE    LIQ           LIQ           LIQ           LIQ           *VMIRFNA0270
C*    CONT     SPH           CYL           SPH           CYL           *VMIRFNA0280
C*    STEMP    300.0 K       300.0 K       300.0 K       300.0 K       *VMIRFNA0290
C*    STIME    INFINITE      INFINITE      INFINITE      INFINITE      *VMIRFNA0300
C*    SPRES    1.25*P0       1.25*P0       1 ATM         1 ATM         *VMIRFNA0310
C*    RFSYS    POS           POS           PFS           PFS           *VMIRFNA0320
C*    MATER    AL            AL            AL            AL            *VMIRFNA0330
C*                                                                     *VMIRFNA0340
C*  INPUT VARIABLES:                                                   *VMIRFNA0350
C*                                                                     *VMIRFNA0360
C*  J      = STORAGE MODE CONTROL VARIABLE                             *VMIRFNA0370
C*  K      = STORAGE MODE CONTROL ARRAY                                *VMIRFNA0380
C*  MIRFNA  = TOTAL DELIVERED MASS OF IRFNA [KG]                       *VMIRFNA0390
C*  P0      = COMBUSTOR OR NOZZLE STAGNATION PRESSURE [PA]             *VMIRFNA0400
C*  RTIME   = RUN TIME [S]                                             *VMIRFNA0410
C*                                                                     *VMIRFNA0420
C*  OUTPUT VARIABLES:                                                  *VMIRFNA0430
C*                                                                     *VMIRFNA0440
C*  MTANK   = TANK MASS [KG]                                           *VMIRFNA0450
C*  STIRFNA = STORAGE MODE DESCRIPTOR DATA ARRAY                       *VMIRFNA0460
C*  STMODE  = STORAGE MODE DESCRIPTOR ARRAY                            *VMIRFNA0470
C*  VTANK   = TANK VOLUME [M3]                                         *VMIRFNA0480
C*                                                                     *VMIRFNA0490
C***********************************************************************VMIRFNA0500
C                                                                       VMIRFNA0510
C                                                                       VMIRFNA0520
      IMPLICIT REAL(M)                                                  VMIRFNA0530
C                                                                       VMIRFNA0540
      COMMON/SCS4/K(10)                                                 VMIRFNA0550
C                                                                       VMIRFNA0560
      COMMON/SCS5/STMODE(10,10)                                         VMIRFNA0570
C                                                                       VMIRFNA0580
      COMMON/SCS13/STIRFNA(10,4)                                        VMIRFNA0590
C                                                                       VMIRFNA0600
      DATA ((STIRFNA(I,K),K=1,4),I=1,10)/                               VMIRFNA0610
     -10HIRFNA     ,10HIRFNA     ,10HIRFNA     ,10HIRFNA     ,          VMIRFNA0620
     -10HLIQ       ,10HLIQ       ,10HLIQ       ,10HLIQ       ,          VMIRFNA0630
     -10HSPH       ,10HCYL       ,10HSPH       ,10HCYL       ,          VMIRFNA0640
```

```
     -10H300.0 K    ,10H300.0 K    ,10H300.0 K    ,10H300.0 K    ,         VMIRFNA0650
     -10HINFINITE   ,10HINFINITE   ,10HINFINITE   ,10HINFINITE   ,         VMIRFNA0660
     -10H           ,10            ,10H           ,10H           ,         VMIRFNA0670
     -10H1.25*P0    ,10H1.25*P0    ,10H1 ATM      ,10H1 ATM      ,         VMIRFNA0680
     -10H           ,10H           ,10H           ,10H           ,         VMIRFNA0690
     -10HP8S        ,10HPGS        ,10HPFS        ,10HPFS        ,         VMIRFNA0700
     -10HAL         ,10HAL         ,10HAL         ,10HAL         /         VMIRFNA0710
C                                                                          VMIRFNA0720
C                                                                          VMIRFNA0730
C*************************************************************************VMIRFNA0740
C*                                                                        *VMIRFNA0750
C*                    SET STORAGE MODE DESCRIPTOR ARRAY                   *VMIRFNA0760
C*                                                                        *VMIRFNA0770
C*************************************************************************VMIRFNA0780
C                                                                          VMIRFNA0790
C                                                                          VMIRFNA0800
      DO 101 I=1,10                                                        VMIRFNA0810
101   STMODE(I,J)=STIRFNA(I,K(J))                                          VMIRFNA0820
C                                                                          VMIRFNA0830
C                                                                          VMIRFNA0840
C*************************************************************************VMIRFNA0850
C*                                                                        *VMIRFNA0860
C*                      CALCULATE TANK VOLUME/MASS                        *VMIRFNA0870
C*                                                                        *VMIRFNA0880
C*************************************************************************VMIRFNA0890
C                                                                          VMIRFNA0900
C                                                                          VMIRFNA0910
      GO TO (102,102,105,106),K(J)                                         VMIRFNA0920
C                                                                          VMIRFNA0930
C                                                                          VMIRFNA0940
C*************************************************************************VMIRFNA0950
C*                                                                        *VMIRFNA0960
C*                      PGS LIQUID STORAGE (300 K)                        *VMIRFNA0970
C*                                                                        *VMIRFNA0980
C*************************************************************************VMIRFNA0990
C                                                                          VMIRFNA1000
C                                                                          VMIRFNA1010
102   AF=1.0/(1.0-(3.11270E-08*P0)**(1.0/1.66498))                         VMIRFNA1020
      Z=4.73661E-09*1.25*P0+1.00003                                        VMIRFNA1030
      MPGS=6.90088E-04*MIRFNA/(4.74797E+05*Z/P0-1.79146E-02*AF)            VMIRFNA1040
      MTTPGS=12.5194*AF*MPGS                                               VMIRFNA1050
     .         +0.904642*(AF*MPGS)**(2.0/3.0)                              VMIRFNA1060
      VTTPGS=1.88103E-02*AF*MPGS                                           VMIRFNA1070
      GO TO (103,104),K(J)                                                 VMIRFNA1080
103   MVT=1.17700*MIRFNA                                                   VMIRFNA1090
     -    +3.05493E-08*P0*MIRFNA                                           VMIRFNA1100
     -    +8.10866E-02*MIRFNA**(2.0/3.0)                                   VMIRFNA1110
      MMT=1.17100*MIRFNA                                                   VMIRFNA1120
     -    +0.195846*MIRFNA**(2.0/3.0)                                      VMIRFNA1130
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS                                    VMIRFNA1140
      VTANK=VTANK+7.59097E-04*MIRFNA+VTTPGS                                VMIRFNA1150
      RETURN                                                               VMIRFNA1160
104   MVT=1.15500*MIRFNA                                                   VMIRFNA1170
     -    +6.70330E-05*P0*MIRFNA                                           VMIRFNA1180
     -    +0.179154*MIRFNA**(2.0/3.0)                                      VMIRFNA1190
```

```
      MMT=1.15500*MIRFNA                                                VMIRFNA1200
     -    +0.432706*MIRFNA**(2.0/3.0)                                   VMIRFNA1210
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS                                 VMIRFNA1220
      VTANK=VTANK+7.59097E-04*MIRFNA+VTTPGS                             VMIRFNA1230
      RETURN                                                            VMIRFNA1240
C                                                                       VMIRFNA1250
C                                                                       VMIRFNA1260
C***********************************************************************VMIRFNA1270
C*                                                                     *VMIRFNA1280
C*                        PFS LIQUID STORAGE (300 K)                   *VMIRFNA1290
C*                                                                     *VMIRFNA1300
C***********************************************************************VMIRFNA1310
C                                                                       VMIRFNA1320
C                                                                       VMIRFNA1330
105   MTANK=MTANK+1.17700*MIRFNA                                        VMIRFNA1340
     -           +0.253226*MIRFNA**(2.0/3.0)                            VMIRFNA1350
     -           +4.11538E-09*P0*MIRFNA                                 VMIRFNA1360
     -           +1.56269E-04*(P0*MIRFNA/RTIME)**(2.0/3.0)              VMIRFNA1370
     -           +1.36650E-02*(P0*MIRFNA/RTIME)**(1.0/3.0)              VMIRFNA1380
      VTANK=VTANK+7.59097E-04*MIRFNA                                    VMIRFNA1390
     -           +4.21192E-12*P0*MIRFNA                                 VMIRFNA1400
     -           +9.86986E-08*(P0*MIRFNA/RTIME)**(2.0/3.0)              VMIRFNA1410
     -           +8.63079E-06*(P0*MIRFNA/RTIME)**(1.0/3.0)              VMIRFNA1420
      RETURN                                                            VMIRFNA1430
106   MTANK=MTANK+1.15500*MIRFNA                                        VMIRFNA1440
     -           +0.559482*MIRFNA**(2.0/3.0)                            VMIRFNA1450
     -           +4.11538E-09*P0*MIRFNA                                 VMIRFNA1460
     -           +1.56269E-04*(P0*MIRFNA/RTIME)**(2.0/3.0)              VMIRFNA1470
     -           +1.36650E-02*(P0*MIRFNA/RTIME)**(1.0/3.0)              VMIRFNA1480
      VTANK=VTANK+7.59097E-04*MIRFNA                                    VMIRFNA1490
     -           +4.21192E-12*P0*MIRFNA                                 VMIRFNA1500
     -           +9.86986E-08*(P0*MIRFNA/RTIME)**(2.0/3.0)              VMIRFNA1510
     -           +8.63079E-06*(P0*MIRFNA/RTIME)**(1.0/3.0)              VMIRFNA1520
      END                                                               VMIRFNA1530
```

```
      SUBROUTINE VMMMH(J,MMMH,P0,RTIME,MTANK,VTANK)                     VMMMH  0100
C                                                                       VMMMH  0110
C                                                                       VMMMH  0120
C***********************************************************************VMMMH  0130
C*                                                                     *VMMMH  0140
C*              MMH TANK VOLUME/MASS   SUBROUTINE (VMMMH)              *VMMMH  0150
C*                                                                     *VMMMH  0160
C***********************************************************************VMMMH  0170
C                                                                       VMMMH  0180
C***********************************************************************VMMMH  0190
C*                                                                     *VMMMH  0200
C*  SUBROUTINE VMMMH CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE   *VMMMH  0210
C*  OF MONOMETHYL HYDRAZINE (CH6N2).                                   *VMMMH  0220
C*                                                                     *VMMMH  0230
C*  MMH MAY BE STORED ANY OF FOUR WAYS:                                *VMMMH  0240
C*                                                                     *VMMMH  0250
C*    K        1             2             3             4             *VMMMH  0260
C*    PHASE    LIQ           LIQ           LIQ           LIQ           *VMMMH  0270
C*    CONT     SPH           CYL           SPH           CYL           *VMMMH  0280
C*    STEMP    300.0 K       300.0 K       300.0 K       300.0 K       *VMMMH  0290
C*    STIME    INFINITE      INFINITE      INFINITE      INFINITE      *VMMMH  0300
C*    SPRES    1.25*P0       1.25*P0       1 ATM         1 ATM         *VMMMH  0310
C*    RFSYS    PGS           PGS           PFS           PFS           *VMMMH  0320
C*    MATER    TI            TI            AL            AL            *VMMMH  0330
C*                                                                     *VMMMH  0340
C*  INPUT VARIABLES:                                                   *VMMMH  0350
C*                                                                     *VMMMH  0360
C*  J      = STORAGE MODE CONTROL VARIABLE                             *VMMMH  0370
C*  K      = STORAGE MODE CONTROL ARRAY                                *VMMMH  0380
C*  MMMH   = TOTAL DELIVERED MASS OF MMH (KG)                          *VMMMH  0390
C*  P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)              *VMMMH  0400
C*  RTIME  = RUN TIME (S)                                              *VMMMH  0410
C*                                                                     *VMMMH  0420
C*  OUTPUT VARIABLES:                                                  *VMMMH  0430
C*                                                                     *VMMMH  0440
C*  MTANK  = TANK MASS (KG)                                            *VMMMH  0450
C*  STMMH  = STORAGE MODE DESCRIPTOR DATA ARRAY                        *VMMMH  0460
C*  STMODE = STORAGE MODE DESCRIPTOR ARRAY                             *VMMMH  0470
C*  VTANK  = TANK VOLUME (M3)                                          *VMMMH  0480
C*                                                                     *VMMMH  0490
C***********************************************************************VMMMH  0500
C                                                                       VMMMH  0510
C                                                                       VMMMH  0520
      IMPLICIT REAL(M)                                                  VMMMH  0530
C                                                                       VMMMH  0540
      COMMON/SCS4/K(10)                                                 VMMMH  0550
C                                                                       VMMMH  0560
      COMMON/SCS5/STMODE(10,10)                                         VMMMH  0570
C                                                                       VMMMH  0580
      COMMON/SCS14/STMMH(10,4)                                          VMMMH  0590
C                                                                       VMMMH  0600
      DATA ((STMMH(I,K),K=1,4),I=1,10)/                                 VMMMH  0610
     -10HMMMH      ,10HMMMH      ,10HMMMH      ,10HMMMH       ,         VMMMH  0620
     -10HLIQ       ,10HLIQ       ,10HLIQ       ,10HLIQ        ,         VMMMH  0630
     -10HSPH       ,10HCYL       ,10HSPH       ,10HCYL        ,         VMMMH  0640
```

```
     -10H300.0 K   ,10H300.0 K   ,10H300.0 K   ,10H300.0 K   ,           VMMMM  0650
     -10HINFINITE  ,10HINFINITE  ,10HINFINITE  ,10HINFINITE  ,           VMMMM  0660
     -10H          ,10H          ,10H          ,10H          ,           VMMMM  0670
     -10H1.25*P0   ,10H1.25*P0   ,10H1 ATM     ,10H1 ATM     ,           VMMMM  0680
     -10H          ,10H          ,10H          ,10H          ,           VMMMM  0690
     -10HPGS       ,10HPGS       ,10HPFS       ,10HPFS       ,           VMMMM  0700
     -10HTI        ,10HTI        ,10HAL        ,10HAL        /           VMMMM  0710
C                                                                        VMMMM  0720
C                                                                        VMMMM  0730
C************************************************************************VMMMM  0740
C*                                                                      *VMMMM  0750
C*                   SET STORAGE MODE DESCRIPTOR ARRAY                  *VMMMM  0760
C*                                                                      *VMMMM  0770
C************************************************************************VMMMM  0780
C                                                                        VMMMM  0790
C                                                                        VMMMM  0800
      DO 101 I=1,10                                                      VMMMM  0810
101   STMODE(I,J)=STMMM(I,K(J))                                          VMMMM  0820
C                                                                        VMMMM  0830
C                                                                        VMMMM  0840
C************************************************************************VMMMM  0850
C*                                                                      *VMMMM  0860
C*                      CALCULATE TANK VOLUME/MASS                      *VMMMM  0870
C*                                                                      *VMMMM  0880
C************************************************************************VMMMM  0890
C                                                                        VMMMM  0900
C                                                                        VMMMM  0910
      GO TO (102,102,105,106),K(J)                                       VMMMM  0920
C                                                                        VMMMM  0930
C                                                                        VMMMM  0940
C************************************************************************VMMMM  0950
C*                                                                      *VMMMM  0960
C*                       PGS LIQUID STORAGE (300 K)                     *VMMMM  0970
C*                                                                      *VMMMM  0980
C************************************************************************VMMMM  0990
C                                                                        VMMMM  1000
C                                                                        VMMMM  1010
102   AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.66498))                       VMMMM  1020
      Z=4.73681E-09*1.25*P0+1.00003                                      VMMMM  1030
      MPGS=1.25858E-03*MMMM/(4.74797E+05*Z/P0-1.79146E-02*AF)            VMMMM  1040
      MTTPGS=12.5194*AF*MPGS                                             VMMMM  1050
     -        +0.904642*(AF*MPGS)**(2.0/3.0)                             VMMMM  1060
      VTTPGS=1.88103E-02*AF*MPGS                                         VMMMM  1070
      GO TO (103,104),K(J)                                               VMMMM  1080
103   MVT=1.17700*MMMM                                                   VMMMM  1090
     -    +2.43051E-08*P0*MMMM                                           VMMMM  1100
     -    +0.121041 [illegible]M**(2.0/3.0)                              VMMMM  1110
      MMT=1.17700*M[illegible]                                           VMMMM  1120
     -    +0.256759*MMMM**(2.0/3.0)                                      VMMMM  1130
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS                                  VMMMM  1140
      VTANK=VTANK+1.38444E-03*MMMM+VTTPGS                                VMMMM  1150
      RETURN                                                             VMMMM  1160
104   MVT=1.15500*MMMM                                                   VMMMM  1170
     -    +3.22308E-08*P0*MMMM                                           VMMMM  1180
     -    +0.267430*MMMM**(2.0/3.0)                                      VMMMM  1190
```

```
      MMT=1.15500*MMMH                                                  VMMMH  1200
     -    +0.567288*MMMH**(2.0/3.0)                                     VMMMH  1210
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS                                 VMMMH  1220
      VTANK=VTANK+1.38444E-03*MMMH+VTTPGS                               VMMMH  1230
      RETURN                                                            VMMMH  1240
C                                                                       VMMMH  1250
C                                                                       VMMMH  12?0
C***********************************************************************VMMMH  12?0
C*                                                                     *VMMMH  12?0
C*                         PFS LIQUID STORAGE (300 K)                  *VMMMH  1290
C*                                                                     *VMMMH  1300
C***********************************************************************VMMMH  1310
C                                                                       VMMMH  1320
C                                                                       VMMMH  1330
105   MTANK=MTANK+1.17700*MMMH                                          VMMMH  1340
     -               +0.378001*MMMH**(2.0/3.0)                          VMMMH  1350
     -               +7.50561E-09*P0*MMMH                               VMMMH  1360
     -               +2.33269E-04*(P0*MMMH/RTIME)**(2.0/3.0)            VMMMH  1370
     -               +1.66956E-02*(P0*MMMH/RTIME)**(1.0/3.0)            VMMMH  1380
      VTANK=VTANK+1.38444E-03*MMMH                                      VMMMH  1390
     -               +7.68168E-12*P0*MMMH                               VMMMH  1400
     -               +1.47331E-07*(P0*MMMH/RTIME)**(2.0/3.0)            VMMMH  1410
     -               +1.05449E-05*(P0*MMMH/RTIME)**(1.0/3.0)            VMMMH  1420
      RETURN                                                            VMMMH  1430
 06   MTANK=MTANK+1.15500*MMMH                                          VMMMH  1440
     -               +0.835161*MMMH**(2.0/3.0)                          VMMMH  1450
     -               +7.50561E-09*P0*MMMH                               VMMMH  1460
     -               +2.33269E-04*(P0*MMMH/RTIME)**(2.0/3.0)            VMMMH  1470
     -               +1.66956E-02*(P0*MMMH/RTIME)**(1.0/3.0)            VMMMH  1480
      VTANK=VTANK+1.38444E-03*MMMH                                      VMMMH  1490
     -               +7.68168E-12*P0*MMMH                               VMMMH  1500
     -               +1.47331E-07*(P0*MMMH/RTIME)**(2.0/3.0)            VMMMH  1510
     -               +1.05449E-05*(P0*MMMH/RTIME)**(1.0/3.0)            VMMMH  1520
      END                                                               VMMMH  1530
```

```
      SUBROUTINE VMNF3(J,MHE,MNF3,P0,MTANK,VTANK)                        VMNF3  0100
C                                                                        VMNF3  0110
C                                                                        VMNF3  0120
C***********************************************************************VMNF3  0130
C*                                                                      *VMNF3  0140
C*                  NF3 TANK VOLUME/MASS SUBROUTINE (VMNF3)             *VMNF3  0150
C*                                                                      *VMNF3  0160
C***********************************************************************VMNF3  0170
C                                                                        VMNF3  0180
C***********************************************************************VMNF3  0190
C*                                                                      *VMNF3  0200
C*   SUBROUTINE VMNF3 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE   *VMNF3  0210
C*   OF NF3.                                                            *VMNF3  0220
C*                                                                      *VMNF3  0230
C*   NF3 MAY BE STORED ANY OF FOUR WAYS; HOWEVER, WHEN STORED AS A GAS, *VMNF3  0240
C*   NF3 IS  STORED WITH  HE AS  A GAS  MIXTURE AT A  PARTIAL  PRESSURE *VMNF3  0250
C*   PNF3 = 1.24106E+07 PA   (1800 PSIA)  PROVIDED HE IS  PRESENT IN THE *VMNF3  0260
C*   SYSTEM:                                                            *VMNF3  0270
C*                                                                      *VMNF3  0280
C*     K        1              2              3              4          *VMNF3  0290
C*     PHASE    GAS            GAS            LIQ            LIQ        *VMNF3  0300
C*     CONT     SPH            CYL            SPH            SPH        *VMNF3  0310
C*     STEMP    300.0 K        300.0 K        77.5 K         77.5 K     *VMNF3  0320
C*     STIME    INFINITE       INFINITE       8.6E+05 S      1.6E+07 S  *VMNF3  0330
C*                                            (10 DAY)       (180 DAY)  *VMNF3  0340
C*     SPRES    1.2E+07 PA     1.2E+07 PA     1.25*P0        1.25*P0    *VMNF3  0350
C*              (1800 PSI)     (1800 PSI)                               *VMNF3  0360
C*     RESYS    BLD            BLD            PGS            PGS        *VMNF3  0370
C*     MATER    SS             SS             SS             SS         *VMNF3  0380
C*                                                                      *VMNF3  0390
C*   INPUT VARIABLES:                                                   *VMNF3  0400
C*                                                                      *VMNF3  0410
C*   J      = STORAGE MODE CONTROL VARIABLE                             *VMNF3  0420
C*   K      = STORAGE MODE CONTROL ARRAY                                *VMNF3  0430
C*   MHE    = TOTAL DELIVERED MASS OF HE [KG]                           *VMNF3  0440
C*   MNF3   = TOTAL DELIVERED MASS OF NF3 [KG]                          *VMNF3  0450
C*   P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE [PA]              *VMNF3  0460
C*                                                                      *VMNF3  0470
C*   OUTPUT VARIABLES:                                                  *VMNF3  0480
C*                                                                      *VMNF3  0490
C*   MTANK  = TANK MASS [KG]                                            *VMNF3  0500
C*   STMODE = STORAGE MODE DESCRIPTOR ARRAY                             *VMNF3  0510
C*   STNF3  = STORAGE MODE DESCRIPTOR DATA ARRAY                        *VMNF3  0520
C*   VTANK  = TANK VOLUME [M3]                                          *VMNF3  0530
C*                                                                      *VMNF3  0540
C***********************************************************************VMNF3  0550
C                                                                        VMNF3  0560
C                                                                        VMNF3  0570
      IMPLICIT REAL(M)                                                   VMNF3  0580
C                                                                        VMNF3  0590
      COMMON/SCS4/K(10)                                                  VMNF3  0600
C                                                                        VMNF3  0610
      COMMON/SCS5/STMODE(10,10)                                          VMNF3  0620
C                                                                        VMNF3  0630
      COMMON/SCS15/STNF3(10,4)                                           VMNF3  0640
```

```
C
       DATA ((STNF3(I,K),K=1,4),I=1,10)/
      -10HNF3       ,10HNF3       ,10HNF3       ,10HNF3       ,
      -10HGAS       ,10HGAS       ,10HLIQ       ,10HLIQ       ,
      -10HSPH       ,10HCYL       ,10HSPH       ,10HSPH       ,
      -10H300.0 K   ,10H300.0 K   ,10H77.5 K    ,10H77.5 K    ,
      -10HINFINITE  ,10HINFINITE  ,10H8.6E+05 S ,10H1.6E+07 S ,
      -10H          ,10H          ,10H(10 DAY)  ,10H(180 DAY) ,
      -10H1.2E+07 PA,10H1.2E+07 PA,10H1.25*P0   ,10H1.25*P0   ,
      -10H(1800 PSI),10H(1800 PSI),10H          ,10H          ,
      -10HBLD       ,10HBLD       ,10HPGS       ,10HPGS       ,
      -10HSS        ,10HSS        ,10HSS        ,10HSS        /
C
C
C**********************************************************************
C*                                                                    *
C*                SET STORAGE MODE DESCPIPTOR ARRAY                   *
C*                                                                    *
C**********************************************************************
C
C
      DO 101 I=1,10
101   STMODE(I,J)=STNF3(I,K(J))
C
C
C**********************************************************************
C*                                                                    *
C*                    CALCULATE TANK VOLUME/MASS                      *
C*                                                                    *
C**********************************************************************
C
C
      GO TO (102,102,105,105),K(J)
C
C
C**********************************************************************
C*                                                                    *
C*                        GAS STORAGE (300 K)                         *
C*                                                                    *
C**********************************************************************
C
C
102   IF(MHE.NE.0.0) STMODE(1,J)=10HNF3/HE
      XFNF3=1.0/(1.0+(71.0019*MHE)/(4.0026*MNF3))
      XFHE=1.0-XFNF3
      PS=1.24106E+07/XFNF3
      PHE=PS-1.24106E+07
      MW=71.0019*(MHE/MNF3+1.0)/(XFHE/XFNF3+1.0)
      G=(2.50092*XFHE/XFNF3+6.44455)/(1.50092*XFHE/XFNF3+5.44455)
      ZHE=4.61576E-09*PHE+1.00053
      Z=0.95*XFNF3+ZHE*XFHE
      AF=1.0/(1.0-(1.25*P0/PS)**(1.0/G))
      MTOTAL=MHE+MNF3
      IF(PS.GT.4.13685E+07) WRITE(6,201)(PS,II=1,9)
      GO TO(103,104),K(J)
```

```
103   MTANK=MTANK+1.10210*(1.0+67.5353*Z/MW)*AF*MTOTAL                 VMNF3  1200
     -              +2.47854E+05*(Z*AF*MTOTAL/(PS*MW))**(2.0/3.0)      VMNF3  1210
      VTANK=VTANK+2.69759E+06*Z*AF*MTOTAL/(PS*MW)                      VMNF3  1220
      RETURN                                                           VMNF3  1230
104   MTANK=MTANK+1.08150*(1.0+91.2639*Z/MW)*AF*MTOTAL                 VMNF3  1240
     -              +5.47613E+05*(Z*AF*MTOTAL/(PS*MW))**(2.0/3.0)      VMNF3  1250
      VTANK=VTANK+2.69759E+06*Z*AF*MTOTAL/(PS*MW)                      VMNF3  1260
      RETURN                                                           VMNF3  1270
C                                                                      VMNF3  1280
C                                                                      VMNF3  1290
C***********************************************************************VMNF3  1300
C*                                                                    *VMNF3  1310
C*                     PGS LIQUID STORAGE (77.5 K)                    *VMNF3  1320
C*                                                                    *VMNF3  1330
C***********************************************************************VMNF3  1340
C                                                                      VMNF3  1350
C                                                                      VMNF3  1360
105   AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.61019))                     VMNF3  1370
      Z=1.74986E-08*1.25*P0+0.999271                                   VMNF3  1380
      MPGS=7.19015E-03*MNF3/(1.22656E+05*Z/P0-6.76795E-03*AF)          VMNF3  1390
      GO TO (106,107),K(J)-2                                           VMNF3  1400
106   MTTPGS=4.71181*AF*MPGS                                           VMNF3  1410
     -        +2.67404*(AF*MPGS)**(2.0/3.0)                            VMNF3  1420
     -        +0.217186*(AF*MPGS)**(1.0/3.0)                           VMNF3  1430
      VTTPGS=7.10635E-03*AF*MPGS                                       VMNF3  1440
     -        +2.76884E-03*(AF*MPGS)**(2.0/3.0)                        VMNF3  1450
     -        +3.57605E-04*(AF*MPGS)**(1.0/3.0)                        VMNF3  1460
      MVT=1.18700*MNF3                                                 VMNF3  1470
     -    +1.70825E-08*P0*MNF3                                         VMNF3  1480
     -    +0.577111*MNF3**(2.0/3.0)                                    VMNF3  1490
     -    +0.102883*MNF3**(1.0/3.0)                                    VMNF3  1500
      MMT=1.18700*MNF3                                                 VMNF3  1510
     -    +0.744061*MNF3**(2.0/3.0)                                    VMNF3  1520
     -    +0.102863*MNF3**(1.0/3.0)                                    VMNF3  1530
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS                                VMNF3  1540
      VTANK=VTANK+7.90917E-04*MNF3                                     VMNF3  1550
     -              +6.50663E-04*MNF3**(2.0/3.0)                       VMNF3  1560
     -              +1.78425E-04*MNF3**(1.0/3.0)                       VMNF3  1570
     -              +VTTPGS                                            VMNF3  1580
      RETURN                                                           VMNF3  1590
107   MTTPGS=4.61764*AF*MPGS                                           VMNF3  1600
     -        +5.92067*(AF*MPGS)**(2.0/3.0)                            VMNF3  1610
     -        +3.53850*(AF*MPGS)**(1.0/3.0)                            VMNF3  1620
      VTTPGS=7.10635E-03*AF*MPGS                                       VMNF3  1630
     -        +1.38442E-02*(AF*MPGS)**(2.0/3.0)                        VMNF3  1640
     -        +8.99017E-03*(AF*MPGS)**(1.0/3.0)                        VMNF3  1650
      MVT=1.17700*MNF3                                                 VMNF3  1660
     -    +1.70825E-08*P0*MNF3                                         VMNF3  1670
     -    +1.30537*MNF3**(2.0/3.0)                                     VMNF3  1680
     -    +1.67589*MNF3**(1.0/3.0)                                     VMNF3  1690
      MMT=1.17700*MNF3                                                 VMNF3  1700
     -    +1.47232*MNF3**(2.0/3.0)                                     VMNF3  1710
     -    +1.67589*MNF3**(1.0/3.0)                                     VMNF3  1720
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS                                VMNF3  1730
      VTANK=VTANK+7.90917E-04*MNF3                                     VMNF3  1740
```

```
     -             +3.25331E-03*MNF3**(2.0/3.0)                            VMNF3  1750
     -             +4.46065E-03*MNF3**(1.0/3.0)                            VMNF3  1760
     -             +VTTPGS                                                 VMNF3  1770
      RETURN                                                               VMNF3  1780
C                                                                          VMNF3  1790
C                                                                          VMNF3  1800
C************* ***********************************************************VMNF3  1810
C*                                                                        *VMNF3  1820
C*                          FORMAT STATEMENTS                             *VMNF3  1830
C*                                                                        *VMNF3  1840
C*************************************************************************VMNF3  1850
C                                                                          VMNF3  1860
C                                                                          VMNF3  1870
201   FORMAT(*1*,T2,*WARNING: STORAGE PRESSURE FOR NF3/HF EXCEEDS 4.1368VMNF3  1880
     -5E+07 PA (6000 PSIA)*,9(/,T2,*PS =*,E13.6,* PA*))                    VMNF3  1890
      END                                                                  VMNF3  1900
```

```
      SUBROUTINE VMN2(J,MN2,P0,RTIME,MTANK,VTANK)                       VMN2
C                                                                       VMN2
C                                                                       VMN2
C***********************************************************************VMN2
C*                                                                     *VMN2
C*                   N2 TANK VOLUME/MASS SUBROUTINE (VMN2)             *VMN2
C*                                                                     *VMN2
C***********************************************************************VMN2
C                                                                       VMN2
C***********************************************************************VMN2
C*                                                                     *VMN2
C*   SUBROUTINE VMN2 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE   *VMN2
C*   OF N2.                                                            *VMN2
C*                                                                     *VMN2
C*  N2 MAY BE STORED ANY OF EIGHT WAYS:                                *VMN2
C*                                                                     *VMN2
C*    K        1              2              3              4          *VMN2
C*    PHASE    GAS            GAS            LIQ            LIQ        *VMN2
C*    CONT     SPH            CYL            SPH            SPH        *VMN2
C*    STEMP    300.0 K        300.0 K        77.5 K         77.5 K     *VMN2
C*    STIME    INFINITE       INFINITE       8.6E+05 S      1.6E+07 S  *VMN2
C*                                           (10 DAY)       (180 DAY)  *VMN2
C*    SPRES    4.1E+07 PA     4.1E+07 PA     1.25*P0        1.25*P0    *VMN2
C*             (6000 PSI)     (6000 PSI)                               *VMN2
C*    RFSYS    BLD            BLD            PGS            PGS        *VMN2
C*    MATER    TI             TI             SS             SS         *VMN2
C*                                                                     *VMN2
C*    K        5              6              7              8          *VMN2
C*    PHASE    LIQ            LIQ            LIQ            LIQ        *VMN2
C*    CONT     SPH            SPH            SPH            SPH        *VMN2
C*    STEMP    77.5 K         77.5 K         77.5 K         77.5 K     *VMN2
C*    STIME    8.6E+05 S      1.6E+07 S      8.6E+05 S      1.6E+07 S  *VMN2
C*             (10 DAY)       (180 DAY)      (10 DAY)       (180 DAY)  *VMN2
C*    SPRES    1 ATM          1 ATM          1.25*P0        1.25*P0    *VMN2
C*    RFSYS    PFS            PFS            HPS            HPS        *VMN2
C*    MATER    AL             AL             SS             SS         *VMN2
C*                                                                     *VMN2
C*  INPUT VARIABLES:                                                   *VMN2
C*                                                                     *VMN2
C*  J      = STORAGE MODE CONTROL VARIABLE                             *VMN2
C*  K      = STORAGE MODE CONTROL ARRAY                                *VMN2
C*  MN2    = TOTAL DELIVERED MASS OF N2 [KG]                           *VMN2
C*  P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE [PA]              *VMN2
C*  RTIME  = RUN TIME [S]                                              *VMN2
C*                                                                     *VMN2
C*  OUTPUT VARIABLES:                                                  *VMN2
C*                                                                     *VMN2
C*  MTANK  = TANK MASS [KG]                                            *VMN2
C*  STMODE = STORAGE MODE DESCRIPTOR ARRAY                             *VMN2
C*  STN2   = STORAGE MODE DESCRIPTOR DATA ARRAY                        *VMN2
C*  VTANK  = TANK VOLUME [M3]                                          *VMN2
C*                                                                     *VMN2
C***********************************************************************VMN2
C                                                                       VMN2
C                                                                       VMN2
```

```
      IMPLICIT REAL(M)                                                  VMN2  0650
C                                                                       VMN2  0660
      COMMON/SCS4/K(10)                                                 VMN2  0670
C                                                                       VMN2  0680
      COMMON/SCS5/STMODE(10,10)                                         VMN2  0690
C                                                                       VMN2  0700
      COMMON/SCS16/STN2(10,8)                                           VMN2  0710
C                                                                       VMN2  0720
      DATA ((STN2(I,K),K=1,4),I=1,10)/                                  VMN2  0730
     -10HN2        ,10HN2        ,10HN2        ,10HN2        ,          VMN2  0740
     -10HGAS       ,10HGAS       ,10HLIQ       ,10HLIQ       ,          VMN2  0750
     -10HSPH       ,10HCYL       ,10HSPH       ,10HSPH       ,          VMN2  0760
     -10H300.0 K   ,10H300.0 K   ,10H77.5 K    ,10H77.5 K    ,          VMN2  0770
     -10HINFINITE  ,10HINFINITE  ,10H8.6E+05 S ,10H1.6E+07 S ,          VMN2  0780
     -10H          ,10H          ,10H(10 DAY)  ,10H(180 DAY) ,          VMN2  0790
     -10H6.1E+07 PA,10H4.1E+07 PA,10H1.25*P0   ,10H1.25*P0   ,          VMN2  0800
     -10H(6000 PSI),10H(6000 PSI),10H          ,10H          ,          VMN2  0810
     -10HBLD       ,10HBLD       ,10HPGS       ,10HPGS       ,          VMN2  0820
     -10HTI        ,10HTI        ,10HSS        ,10HSS        /          VMN2  0830
      DATA ((STN2(I,K),K=5,8),I=1,10)/                                  VMN2  0840
     -10HN2        ,10HN2        ,10HN2        ,10HN2        ,          VMN2  0850
     -10HLIQ       ,10HLIQ       ,10HLIQ       ,10HLIQ       ,          VMN2  0860
     -10HSPH       ,10HSPH       ,10HSPH       ,10HSPH       ,          VMN2  0870
     -10H77.5 K    ,10H77.5 K    ,10H77.5 K    ,10H77.5 K    ,          VMN2  0880
     -10H8.6E+05 S ,10H1.6E+07 S ,10H8.6E+05 S ,10H1.6E+07 S ,          VMN2  0890
     -10H(10 DAY)  ,10H(180 DAY) ,10H(10 DAY)  ,10H(180 DAY) ,          VMN2  0900
     -10H1 ATM     ,10H1 ATM     ,10H1.25*P0   ,10H1.25*P0   ,          VMN2  0910
     -10H          ,10H          ,10H          ,10H          ,          VMN2  0920
     -10HPFS       ,10HPFS       ,10HHPS       ,10HHPS       ,          VMN2  0930
     -10HAL        ,10HAL        ,10HSS        ,10HSS        /          VMN2  0940
C                                                                       VMN2  0950
C                                                                       VMN2  0960
C***********************************************************************VMN2  0970
C*                                                                     *VMN2  0980
C*                   SET STORAGE MODE DESCRIPTOR ARRAY                 *VMN2  0990
C*                                                                     *VMN2  1000
C***********************************************************************VMN2  1010
C                                                                       VMN2  1020
C                                                                       VMN2  1030
      DO 101 I=1,10                                                     VMN2  1040
101   STMODE(I,J)=STN2(I,K(J))                                          VMN2  1050
C                                                                       VMN2  1060
C                                                                       VMN2  1070
C***********************************************************************VMN2  1080
C*                                                                     *VMN2  1090
C*                     CALCULATE TANK VOLUME/MASS                      *VMN2  1100
C*                                                                     *VMN2  1110
C***********************************************************************VMN2  1120
C                                                                       VMN2  1130
C                                                                       VMN2  1140
      GO TO (102,102,105,105,108,109,110,110),K(J)                      VMN2  1150
C                                                                       VMN2  1160
C                                                                       VMN2  1170
C***********************************************************************VMN2  1180
C*                                                                     *VMN2  1190
```

```
C*                       GAS STORAGE (300 K)                              *
C*                                                                        *
C*************************************************************************
C
C
  102 AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.27725))
      GO TO (103,104),K(J)
  103 MTANK=MTANK+2.89274*AF*MN2
     -            +0.262599*(AF*MN2)**(2.0/3.0)
      VTANK=VTANK+2.94186E-03*AF*MN2
      RETURN
  104 MTANK=MTANK+3.45605*AF*MN2
     -            +0.580192*(AF*MN2)**(2.0/3.0)
      VTANK=VTANK+2.94186E-03*AF*MN2
      RETURN
C
C
C*************************************************************************
C*                                                                        *
C*                    PGS LIQUID STORAGE (77.5 K)                         *
C*                                                                        *
C*************************************************************************
C
C
  105 AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.61019))
      Z=1.74986E-08*1.25*P0+0.999271
      MPGS=1.36036E-02*MN2/(1.22656E+03*Z/P0-6.76795E-03*AF)
      GO TO (105,107),K(J)-2
  106 MTTPGS=4.71181*AF*MPGS
     -        +2.67484*(AF*MPGS)**(2.0/3.0)
     -        +0.217186*(AF*MPGS)**(1.0/3.0)
      VTTPGS=7.10635E-03*AF*MPGS
     -        +2.76884E-03*(AF*MPGS)**(2.0/3.0)
     -        +3.59605E-04*(AF*MPGS)**(1.0/3.0)
      MVT=1.19593*MN2
     -   +2.15464E-08*P0*MN2
     -   +0.882813*MN2**(2.0/3.0)
     -   +0.127222*MN2**(1.0/3.0)
      MMT=1.19593*MN2
     -   +1.13820*MN2**(2.0/3.0)
     -   +0.127222*MN2**(1.0/3.0)
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS
      VTANK=VTANK+1.49639E-03*MN2
     -            +9.95326E-04*MN2**(2.0/3.0)
     -            +2.20679E-04*MN2**(1.0/3.0)
     -            +VTTPGS
      RETURN
  107 MTTPGS=4.61764*AF*MPGS
     -        +5.92067*(AF*MPGS)**(2.0/3.0)
     -        +3.53850*(AF*MPGS)**(1.0/3.0)
      VTTPGS=7.10635E-03*AF*MPGS
     -        +1.38442E-02*(AF*MPGS)**(2.0/3.0)
     -        +8.99017E-03*(AF*MPGS)**(1.0/3.0)
      MVT=1.17700*MN2
     -   +2.15464E-08*P0*MN2
```

```
     -    +1.99684*MN2**(2.0/3.0)
     -    +2.07277*MN2**(1.0/3.0)
      MMT=1.17700*MN2
     -    +2.25223*MN2**(2.0/3.0)
     -    +2.07277*MN2**(1.0/3.0)
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS
      VTANK=VTANK+1.49639E-03*MN2
     -               +4.97663E-03*MN2**(2.0/3.0)
     -               +5.51700E-03*MN2**(1.0/3.0)
     -               +VTTPGS
      RFTURN
C
C
C***********************************************************************
C*                                                                     *
C*                       PFS LIOUID STORAGE (77.5 K)                   *
C*                                                                     *
C***********************************************************************
C
C
108   MTANK=MTANK+1.19593*MN2
     -               +1.15344*MN2**(2.0/3.0)
     -               +0.127222*MN2**(1.0/3.0)
     -               +8.11256E-09*P0*MN2
     -               +2.45681E-04*(P0*MN2/RTIME)**(2.0/3.0)
     -               +1.71340E-02*(P0*MN2/RTIME)**(1.0/3.0)
      VTANK=VTANK+1.49639E-03*MN2
     -               +9.95326E-04*MN2**(2.0/3.0)
     -               +2.20679E-04*MN2**(1.0/3.0)
     -               +8.30287E-12*P0*MN2
     -               +1.55171E-07*(P0*MN2/RTIME)**(2.0/3.0)
     -               +1.08218E-05*(P0*MN2/RTIME)**(1.0/3.0)
      RETURN
109   MTANK=MTANK+1.17700*MN2
     -               +2.26748*MN2**(2.0/3.0)
     -               +2.07277*MN2**(1.0/3.0)
     -               +8.11256E-09*P0*MN2
     -               +2.45681E-04*(P0*MN2/RTIME)**(2.0/3.0)
     -               +1.71340E-02*(P0*MN2/RTIME)**(1.0/3.0)
      VTANK=VTANK+1.49639E-03*MN2
     -               +4.97663E-03*MN2**(2.0/3.0)
     -               +5.51700E-03*MN2**(1.0/3.0)
     -               +8.30287E-12*P0*MN2
     -               +1.55171E-07*(P0*MN2/RTIME)**(2.0/3.0)
     -               +1.08218E-05*(P0*MN2/RTIME)**(1.0/3.0)
      RETURN
C
C
C***********************************************************************
C*                                                                     *
C*                       HPS LIQUID STORAGE (77.5 K)                   *
C*                                                                     *
C***********************************************************************
C
C
```

```
110    MTTHPS=2.90075E-06*P0*MN2/RTIME                                    VMN2   2300
       VTTHPS=6.50262E-09*P0*MN2/RTIME                                    VMN2   2310
       GO TO (111,112),K(J)-6                                             VMN2   2320
111    MVT=1.19593*MN2                                                    VMN2   2330
     -    +2.15464E-08*P0*MN2                                             VMN2   2340
     -    +0.882813*MN2**(2.0/3.0)                                        VMN2   2350
     -    +0.127222*MN2**(1.0/3.0)                                        VMN2   2360
       MMT=1.19593*MN2                                                    VMN2   2370
     -    +1.13820*MN2**(2.0/3.0)                                         VMN2   2380
     -    +0.127222*MN2**(1.0/3.0)                                        VMN2   2390
       MTANK=MTANK+AMAX1(MVT,MMT)+MTTHPS                                  VMN2   2400
       VTANK=VTANK+1.49639E-03*MN2                                        VMN2   2410
     -              +9.95326E-04*MN2**(2.0/3.0)                           VMN2   2420
     -              +2.20679E-04*MN2**(1.0/3.0)                           VMN2   2430
     -              +VTTHPS                                               VMN2   2440
       RETURN                                                             VMN2   2450
112    MVT=1.17700*MN2                                                    VMN2   2460
     -    +2.15464E-08*P0*MN2                                             VMN2   2470
     -    +1.99684*MN2**(2.0/3.0)                                         VMN2   2480
     -    +2.07277*MN2**(1.0/3.0)                                         VMN2   2490
       MMT=1.17700*MN2                                                    VMN2   2500
     -    +2.25223*MN2**(2.0/3.0)                                         VMN2   2510
     -    +2.07277*MN2**(1.0/3.0)                                         VMN2   2520
       MTANK=MTANK+AMAX1(MVT,MMT)+MTTHPS                                  VMN2   2530
       VTANK=VTANK+1.49639E-03*MN2                                        VMN2   2540
     -              +4.97663E-03*MN2**(2.0/3.0)                           VMN2   2550
     -              +5.51700E-03*MN2**(1.0/3.0)                           VMN2   2560
     -              +VTTHPS                                               VMN2   2570
       END                                                                VMN2   2580
```

```
      SUBROUTINE VMN2H4(J,MN2H4,P0,RTIME,MTANK,VTANK)
C
C
C***********************************************************************
C*                                                                     *
C*                N2H4 TANK VOLUME/MASS SUBROUTINE (VMN2H4)            *
C*                                                                     *
C***********************************************************************
C
C***********************************************************************
C*                                                                     *
C*  SUBROUTINE VMN2H4 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE  *
C*  OF MONOPROPELLANT HYDRAZINE (N2H4).                                *
C*                                                                     *
C*  N2H4 MAY BE STORED ANY OF FOUR WAYS:                               *
C*                                                                     *
C*    K        1              2              3              4          *
C*    PHASE    LIQ            LIQ            LIQ            LIQ        *
C*    CONT     SPH            CYL            SPH            CYL        *
C*    STEMP    300.0 K        300.0 K        300.0 K        300.0 K    *
C*    STIME    INFINITE       INFINITE       INFINITE       INFINITE   *
C*    SPRES    1.25*P0        1.25*P0        1 ATM          1 ATM      *
C*    PESYS    PGS            PGS            PFS            PFS        *
C*    MATSR    TI             TI             AL             AL         *
C*                                                                     *
C*  INPUT VARIABLES:                                                   *
C*                                                                     *
C*  J       = STORAGE MODE CONTROL VARIABLE                            *
C*  K       = STORAGE MODE CONTROL ARRAY                               *
C*  MN2H4   = TOTAL DELIVERED MASS OF N2H4 (KG)                        *
C*  P0      = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)             *
C*  RTIME   = RUN TIME (S)                                             *
C*                                                                     *
C*  OUTPUT VARIABLES:                                                  *
C*                                                                     *
C*  MTANK   = TANK MASS (KG)                                           *
C*  STN2H4  = STORAGE MODE DESCRIPTOR DATA ARRAY                       *
C*  VTANK   = TANK VOLUME (M3)                                         *
C*                                                                     *
C***********************************************************************
C
C
      IMPLICIT REAL(M)
C
      COMMON/SCS4/K(10)
C
      COMMON/SCS5/STMODE(10,10)
C
      COMMON/SCS17/STN2H4(10,4)
C
      DATA ((STN2H4(I,K),K=1,4),I=1,10)/
     -10HN2H4      ,10HN2H4      ,10HN2H4      ,10HN2H4      ,
     -10HLIQ       ,10HLIQ       ,10HLIQ       ,10HLIQ       ,
     -10HSPH       ,10HCYL       ,10HSPH       ,10HCYL       ,
     -10H300.0 K   ,10H300.0 K   ,10H300.0 K   ,10H300.0 K   ,
```

```
     -10HINFINITE  ,10HINFINITE  ,10HINFINITE  ,10HINFINITE  ,
     -10H          ,10H          ,10H          ,10H          ,
     -10H1.25*P0   ,10H1.25*P0   ,10H1 ATM     ,10H1 ATM     ,
     -10H          ,10H          ,10H          ,10H          ,
     -10HPGS       ,10HPGS       ,10HPFS       ,10HPFS       ,
     -10HTI        ,10HTI        ,10HAL        ,10HAL        /
C
C
C***********************************************************************
C*                                                                     *
C*                  SET STORAGE MODE DESCRIPTOR ARRAY                  *
C*                                                                     *
C***********************************************************************
C
C
      DO 101 I=1,10
101   STMODE(I,J)=STN2H4(I,K(J))
C
C
C***********************************************************************
C*                                                                     *
C*                     CALCULATE TANK VOLUME/MASS                      *
C*                                                                     *
C***********************************************************************
C
C
      GO TO (102,102,105,106),K(J)
C
C
C***********************************************************************
C*                                                                     *
C*                     PGS LIQUID STORAGE (300 K)                      *
C*                                                                     *
C***********************************************************************
C
C
102   AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.66498))
      Z=4.73461E-09*1.25*P0+1.00003
      MPGS=1.09122E-02*MN2H4/(4.74797E+05*Z/P0-1.79146E-02*AF)
      MTTPGS=12.5194*AF*MPGS
     -       +0.904642*(AF*MPGS)**(2.0/3.0)
      VTTPGS=1.88103E-02*AF*MPGS
      GO TO (103,104),K(J)
103   MVT=1.17700*MN2H4
     -    +2.10730E-08*P0*MN2H4
     -    +0.110058*MN2H4**(2.0/3.0)
      MMT=1.17700*MN2H4
     -    +0.233460*MN2H4**(2.0/3.0)
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS
      VTANK=VTANK+1.20034E-03*MN2H4+VTTPGS
      RETURN
104   MVT=1.15500*MN2H4
     -    +2.79448E-08*P0*MN2H4
     -    +0.243163*MN2H4**(2.0/3.0)
      MMT=1.15500*MN2H4
```

```
     -   +0.515811*MN2H4**(2.0/3.0)                                     VMN2H4 1200
      MTANK=MTANK+AMAX1(MVT,MMT)+MTTPGS                                 VMN2H4 1210
      VTANK=VTANK+1.20034E-03*MN2H4+VTTPGS                              VMN2H4 1220
      RETURN                                                            VMN2H4 1230
C                                                                       VMN2H4 1240
C                                                                       VMN2H4 1250
C***********************************************************************VMN2H4 1260
C*                                                                     *VMN2H4 1270
C*                      PFS LIQUID STORAGE (300 K)                     *VMN2H4 1280
C*                                                                     *VMN2H4 1290
C***********************************************************************VMN2H4 1300
C                                                                       VMN2H4 1310
C                                                                       VMN2H4 1320
105   MTANK=MTANK+1.17700*MN2H4                                         VMN2H4 1330
     -           +0.343700*MN2H4**(2.0/3.0)                             VMN2H4 1340
     -           +6.50752E-09*P0*MN2H4                                  VMN2H4 1350
     -           +2.12101E-04*(P0*MN2H4/RTIME)**(2.0/3.0)               VMN2H4 1360
     -           +1.59201E-02*(P0*MN2H4/RTIME)**(1.0/3.0)               VMN2H4 1370
      VTANK=VTANK+1.20034E-03*MN2H4                                     VMN2H4 1380
     -           +6.66019E-12*P0*MN2H4                                  VMN2H4 1390
     -           +1.33962E-07*(P0*MN2H4/RTIME)**(2.0/3.0)               VMN2H4 1400
     -           +1.00551E-05*(P0*MN2H4/RTIME)**(1.0/3.0)               VMN2H4 1410
      RETURN                                                            VMN2H4 1420
106   MTANK=MTANK+1.15500*MN2H4                                         VMN2H4 1430
     -           +0.759376*MN2H4**(2.0/3.0)                             VMN2H4 1440
     -           +6.50752E-09*P0*MN2H4                                  VMN2H4 1450
     -           +2.12101E-04*(P0*MN2H4/RTIME)**(2.0/3.0)               VMN2H4 1460
     -           +1.59201E-02*(P0*MN2H4/RTIME)**(1.0/3.0)               VMN2H4 1470
      VTANK=VTANK+1.20034E-03*MN2H4                                     VMN2H4 1480
     -           +6.66019E-12*P0*MN2H4                                  VMN2H4 1490
     -           +1.33962E-07*(P0*MN2H4/RTIME)**(2.0/3.0)               VMN2H4 1500
     -           +1.00551E-05*(P0*MN2H4/RTIME)**(1.0/3.0)               VMN2H4 1510
      END                                                               VMN2H4 1520
```

Appendix F. NOMENCLATURE – OVERLAY MAIN

NOMENCLATURE FOR PROGRAM MAIN

AEXP = DUMMY NAMELIST VARIABLE
ALPHA = DUMMY NAMELIST VARIABLE
A3A2 = DUMMY NAMELIST VARIABLE
A7A6 = DUMMY NAMELIST VARIABLE
BRFRAC = DUMMY NAMELIST VARIABLE
CANGLE = DUMMY NAMELIST VARIABLE
CCS = ALPHANUMERIC SYMBOL DESIGNATING THE COMBUSTION CHEMISTRY SECTION
CCS1 = DUMMY BLOCK COMMON VARIABLE
CCS9 = DUMMY BLOCK COMMON VARIABLE
CCS10 = DUMMY BLOCK COMMON VARIABLE
CCS13 = DUMMY BLOCK COMMON VARIABLE
CCS14 = DUMMY BLOCK COMMON VARIABLE
CCS15 = DUMMY BLOCK COMMON VARIABLE
CCS16 = DUMMY BLOCK COMMON VARIABLE
CHOKE = ALPHANUMERIC SYMBOL DESIGNATING CHOKED FLOW
D1 = DUMMY NAMELIST VARIABLE
D1S = DUMMY NAMELIST VARIABLE
D3 = DUMMY NAMELIST VARIABLE
D3S = DUMMY NAMELIST VARIABLE
ETA12 = DUMMY NAMELIST VARIABLE
FAIL = ERROR FLAG
FLOW = CHOKED/SEPARATED/SUBSONIC/SUPERSONIC FLOW FLAG
G5 = DUMMY NAMELIST VARIABLE
MNB = DUMMY NAMELIST VARIABLE
LCAV = DUMMY NAMELIST VARIABLE
LDS = ALPHANUMERIC SYMBOL DESIGNATING THE LASER DEVICE SECTION
LDS1 = DUMMY BLOCK COMMON VARIABLE
LPNOZ = DUMMY NAMELIST VARIABLE
LSNOZ = DUMMY NAMELIST VARIABLE
MW5 = DUMMY NAMELIST VARIABLE
NBANK = DUMMY NAMELIST VARIABLE
NEJECT = DUMMY NAMELIST VARIABLE
NO = ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NSPNOZ = DUMMY NAMELIST VARIABLE
N1 = DUMMY NAMELIST VARIABLE
N2 = DUMMY NAMELIST VARIABLE
N3 = DUMMY NAMELIST VARIABLE
N4 = DUMMY NAMELIST VARIABLE
PKFRAC = DUMMY NAMELIST VARIABLE
PRS = ALPHANUMERIC SYMBOL DESIGNATING THE PRESSURE RECOVERY SECTION
PRS1 = DUMMY BLOCK COMMON VARIABLE
P10 = DUMMY NAMELIST VARIABLE
P50 = DUMMY NAMELIST VARIABLE
P7 = DUMMY NAMELIST VARIABLE
RECALL = ALPHANUMERIC SYMBOL FOR AN OVERLAY RECALL OPTION
RTIME = DUMMY NAMELIST VARIABLE
RUN = CONTROL VARIABLE TO STOP OR RESTART THE PROGRAM
SCS = ALPHANUMERIC SYMBOL DESIGNATING THE SYSTEM CALCULATION SECTION
SCS4 = DUMMY BLOCK COMMON VARIABLE
SETCCS = CONTROL VARIABLE TO SET DEFAULT VALUES IN SUBROUTINE INCCS
SETLDS = CONTROL VARIABLE TO SET DEFAULT VALUES IN SUBROUTINE INLDS

```
SETPRS   = CONTROL VARIABLE TO SET DEFAULT VALUES IN SUBROUTINE INPRS
SETSCS   = CONTROL VARIABLE TO SET DEFAULT VALUES IN SUBROUTINE INSCS
T10      = DUMMY NAMELIST VARIABLE
T30      = DUMMY NAMELIST VARIABLE
T50      = DUMMY NAMELIST VARIABLE
T70      = DUMMY NAMELIST VARIABLE
WPG      = DUMMY NAMELIST VARIABLE
WPP3     = DUMMY NAMELIST VARIABLE
WPR1     = DUMMY NAMELIST VARIABLE
WPR2     = DUMMY NAMELIST VARIABLE
WPR3     = DUMMY NAMELIST VARIABLE
WPR4     = DUMMY NAMELIST VARIABLE
WSR1     = DUMMY NAMELIST VARIABLE
WSR2     = DUMMY NAMELIST VARIABLE
WSR3     = DUMMY NAMELIST VARIABLE
YES      = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE
```

NOMENCLATURE FOR SUBROUTINE OUTENG

VARIABLE DEFINITIONS FOR SUBROUTINE OUTENG ARE IDENTICAL TO THOSE GIVEN FOR SUBROUTINES OUTCCS, OUTLOS, OUTPRS, AND OUTSCS. ONLY THE UNITS HAVE BEEN CHANGED FROM THE SI SYSTEM TO A MIXTURE OF ENGINEERING UNITS.

```
          COMBUSTION CHEMISTRY SECTION GENERAL NOTATION SCHEME

VARIABLES ARE DEFINED AS FOLLOWS :

PREFIX:

W        = MASS FLOW RATE
WF       = MASS FRACTION
X        = MOLAR FLOW RATE
XF       = MOLE FRACTION

SUFFIX:

CP       = CAVITY PRODUCT
PG       = MIRROR PURGE
PP       = PRIMARY COMBUSTOR PRODUCT
PR       = PRIMARY COMBUSTOR REACTANT
SR       = SECONDARY REACTANT

EXAMPLE: XFPP1 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 1

LASER PRIMARY COMBUSTOR REACTANTS:

PR1      = C-N1 H-N2  (C-N1 D-N2)
PR2      = HE
PR3      = N2
PR4      = N-N3 F-N4

LASER SECONDARY REACTANTS:

SR1      = D2   (H2)
SR2      = HE
SR3      = N2

LASER PRIMARY COMBUSTOR PRODUCTS:

PP1      = CF4
PP2      = F2
PP3      = F
PP4      = HF   (DF)
PP5      = HE
PP6      = N2

LASER CAVITY PRODUCTS:

CP1      = CF4
CP2      = HF
CP3      = DF
CP4      = HE
CP5      = N2
CP6      = D   (H)

NOTE: REACTANTS AND PRODUCTS ARE DEFINED FOR BOTH DF AND HF CHEMISTRY.
      SPECIES IN PARENTHESIS ARE FOR HF CHEMISTRY.
```

ALL VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED IN THE NOMENCLATURE FOR THE PROGRAM OR SUBROUTINE WHERE THEY APPEAR.

NOMENCLATURE FOR PROGRAM CCS AND SUBROUTINES INCCS, OUTCCS

AEXP = NOZZLE BANK AREA OF THE EXPERIMENTAL DEVICE [M2]
ALPHA = FLUORINE DISSOCIATION FRACTION
CCSS1 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW COMBUSTION CHEMISTRY INPUTS ARE REQUIRED
CCSS2 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT INPUT DATA SHOULD BE READ FROM TAPE1
DF = ALPHANUMERIC SYMBOL DESIGNATING DF LASER CHEMISTRY
DFORHF = CONTROL VARIABLE SUCH THAT:
= "DF" FOR DF CHEMICAL LASER
= "HF" FOR HF CHEMICAL LASER
D2F = HEAT OF COMBUSTION [J/KMOLE] FOR THE REACTION $D_2 + F = DF + D$
D2F2 = HEAT OF COMBUSTION [J/KMOLE] FOR THE REACTION $D_2 + F_2 = 2DF$
FDAA = FREE FLUORINE FLUX (KMOLE/S-M2)
HF = ALPHANUMERIC SYMBOL DESIGNATING HF LASER CHEMISTRY
H2F = HEAT OF COMBUSTION [J/KMOLE] FOR THE REACTION $H_2 + F = HF + H$
H2F2 = HEAT OF COMBUSTION [J/KMOLE] FOR THE REACTION $H_2 + F_2 = 2HF$
NO = ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
N1 = NUMBER OF CARBON ATOMS IN PRIMARY COMBUSTOR REACTANT 1
N2 = NUMBER OF HYDROGEN (DEUTERIUM) ATOMS IN PRIMARY COMBUSTOR REACTANT 1
N3 = NUMBER OF NITROGEN ATOMS IN PRIMARY COMBUSTOR REACTANT 4
N4 = NUMBER OF FLUORINE ATOMS IN PRIMARY COMBUSTOR REACTANT 4
OMEGA = TOTAL LASER MOLAR DILUENT RATIO
OMEGTRW = TOTAL LASER MOLAR DILUENT RATIO (TRW DEFINITION)
PSIC = MOLAR COMBUSTOR DILUENT RATIO
PSIL = MOLAR CAVITY DILUENT RATIO
PSILTRW = MOLAR CAVITY DILUENT RATIO (TRW DEFINITION)
Q = HEAT RELEASED PER KMOLE OF PRIMARY COMBUSTOR FLOW BY THE CHEMICAL REACTION OF FLUORINE IN THE LASER CAVITY [J/KMOLE]
RC = MOLAR COMBUSTOR MIXTURE RATIO
RDATE = ALPHANUMERIC SYMBOL FOR THE COMPUTER RUN DATE
RL = MOLAR CAVITY MIXTURE RATIO
RLF = TOTAL LASER CAVITY MIXTURE RATIO
SETCCS = CONTROL VARIABLE TO SET DEFAULT VALUES
WCPTOT = TOTAL CAVITY PRODUCT MASS FLOW RATE [KG/S]
WCP1 = MASS FLOW RATE OF CAVITY PRODUCT 1, CF4 [KG/S]
WCP2 = MASS FLOW RATE OF CAVITY PRODUCT 2, HF [KG/S]
WCP3 = MASS FLOW RATE OF CAVITY PRODUCT 3, DF [KG/S]
WCP4 = MASS FLOW RATE OF CAVITY PRODUCT 4, HF [KG/S]
WCP5 = MASS FLOW RATE OF CAVITY PRODUCT 5, N2 [KG/S]
WCP6 = MASS FLOW RATE OF CAVITY PRODUCT 6, D (H) [KG/S]
WFCP1 = MASS FRACTION OF CAVITY PRODUCT 1, CF4
WFCP2 = MASS FRACTION OF CAVITY PRODUCT 2, HF
WFCP3 = MASS FRACTION OF CAVITY PRODUCT 3, DF
WFCP4 = MASS FRACTION OF CAVITY PRODUCT 4, HE
WFCP5 = MASS FRACTION OF CAVITY PRODUCT 5, N2
WFCP6 = MASS FRACTION OF CAVITY PRODUCT 6, D (H)
WFPP1 = MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 1, CF4

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WFPP2     = MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 2, F2
WFPP3     = MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 3, F
WFPP4     = MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF)
WFPP5     = MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 5, HE
WFPP6     = MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 6, N2
WFPR1     = MASS FRACTION OF PRIMARY COMBUSTOR REACTANT 1, C-N1 H-N2
            (C-N1 D-N2)
WFPR2     = MASS FRACTION OF PRIMARY COMBUSTOR REACTANT 2, HE
WFPR3     = MASS FRACTION OF PRIMARY COMBUSTOR REACTANT 3, N2
WFPR4     = MASS FRACTION OF PRIMARY COMBUSTOR REACTANT 4, N-N3 F-N4
WFSR1     = MASS FRACTION OF SECONDARY REACTANT 1, D2 (H2)
WFSR2     = MASS FRACTION OF SECONDARY REACTANT 2, HE
WFSR3     = MASS FRACTION OF SECONDARY REACTANT 3, N2
WPG       = MASS FLOW RATE OF MIRROR PURGE N2 [KG/S]
WPGWPP    = MIRROR PURGE-TO-PRIMARY COMBUSTOR PRODUCT MASS FLOW RATIO
WPPTOT    = TOTAL MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCTS     [KG/S]
WPP1      = MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 1, CF4     [KG/S]
WPP2      = MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 2, F2      [KG/S]
WPP3      = MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 3, F       [KG/S]
WPP4      = MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF) [KG/S]
WPP5      = MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 5, HE      [KG/S]
WPP6      = MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 6, N2      [KG/S]
WPRTOT    = TOTAL MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANTS [KG/S]
WPR1      = MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANT 1, C-N1 H-N2
            (C-N1 D-N2) [KG/S]
WPR2      = MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANT 2, HE [KG/S]
WPR3      = MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANT 3, N2 [KG/S]
WPR4      = MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANT 4, N-N1 F-N2
            [KG/S]
WSRTOT    = TOTAL MASS FLOW RATE OF SECONDARY REACTANTS     [KG/S]
WSR1      = MASS FLOW RATE OF SECONDARY REACTANT 1, D2 (H2) [KG/S]
WSR2      = MASS FLOW RATE OF SECONDARY REACTANT 2, HE      [KG/S]
WSR3      = MASS FLOW RATE OF SECONDARY REACTANT 3, N2      [KG/S]
XCPTOT    = TOTAL MOLAR FLOW RATE OF CAVITY PRODUCTS   [KMOLE/S]
XCP1      = MOLAR FLOW RATE OF CAVITY PRODUCT 1, CF4   [KMOLE/S]
XCP2      = MOLAR FLOW RATE OF CAVITY PRODUCT 2, HF    [KMOLE/S]
XCP3      = MOLAR FLOW RATE OF CAVITY PRODUCT 3, DF    [KMOLE/S]
XCP4      = MOLAR FLOW RATE OF CAVITY PRODUCT 4, HE    [KMOLE/S]
XCP5      = MOLAR FLOW RATE OF CAVITY PRODUCT 5, N2    [KMOLE/S]
XCP6      = MOLAR FLOW RATE OF CAVITY PRODUCT 6, D (H) [KMOLE/S]
XFCP1(1)  = MOLE FRACTION OF CAVITY PRODUCT 1, CF4,   W/O MIRROR PURGE
     (2)  = MOLE FRACTION OF CAVITY PRODUCT 1, CF4,   WITH MIRROR PURGE
XFCP2(1)  = MOLE FRACTION OF CAVITY PRODUCT 2, HF,    W/O MIRROR PURGE
     (2)  = MOLE FRACTION OF CAVITY PRODUCT 2, HF,    WITH MIRROR PURGE
XFCP3(1)  = MOLE FRACTION OF CAVITY PRODUCT 3, DF,    W/O MIRROR PURGE
     (2)  = MOLE FRACTION OF CAVITY PRODUCT 3, DF,    WITH MIRROR PURGE
XFCP4(1)  = MOLE FRACTION OF CAVITY PRODUCT 4, HE,    W/O MIRROR PURGE
     (2)  = MOLE FRACTION OF CAVITY PRODUCT 4, HE,    WITH MIRROR PURGE
XFCP5(1)  = MOLE FRACTION OF CAVITY PRODUCT 5, N2,    W/O MIRROR PURGE
     (2)  = MOLE FRACTION OF CAVITY PRODUCT 5, N2,    WITH MIRROR PURGE
XFCP6(1)  = MOLE FRACTION OF CAVITY PRODUCT 6, D (H), W/O MIRROR PURGE
     (2)  = MOLE FRACTION OF CAVITY PRODUCT 6, D (H), WITH MIRROR PURGE
XFPP1     = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 1, CF4
XFPP2     = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 2, F2
XFPP3     = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 3, F
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XFPP4 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF)
XFPP5 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 5, HE
XFPP6 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 6, N2
XFPR1 = MOLE FRACTION OF PRIMARY COMBUSTOR REACTANT 1, C-N1 H-N2 (C-N1 D-N2)
XFPR2 = MOLE FRACTION OF PRIMARY COMBUSTOR REACTANT 2, HE
XFPR3 = MOLE FRACTION OF PRIMARY COMBUSTOR REACTANT 3, N2
XFPR4 = MOLE FRACTION OF PRIMARY COMBUSTOR REACTANT 4, N-N3 F-N4
XFSR1 = MOLE FRACTION OF SECONDARY REACTANT 1, D2 (H2)
XFSR2 = MOLE FRACTION OF SECONDARY REACTANT 2, HE
XFSR3 = MOLE FRACTION OF SECONDARY REACTANT 3, N2
XPPTOT = TOTAL MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCTS [KMOLE/S]
XPP1 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 1, CF4 [KMOLE/S]
XPP2 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 2, F2 [KMOLE/S]
XPP3 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 3, F [KMOLE/S]
XPP3TM = MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 3, F [KMOLE/S], FOR TOTAL FLUORINE DISSOCIATION
XPP4 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF) [KMOLE/S]
XPP5 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 5, HE [KMOLE/S]
XPP6 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 6, N2 [KMOLE/S]
XPRTOT = TOTAL MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANTS [KMOLE/S]
XPR1 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANT 1, C-N1 H-N2 (C-N1 D-N2) [KMOLE/S]
XPR2 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANT 2, HE [KMOLE/S]
XPR3 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANT 3, N2 [KMOLE/S]
XPR4 = MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANT 4, N-N1 F-N2 [KMOLE/S]
XSRTOT = TOTAL MOLAR FLOW RATE OF SECONDARY REACTANTS [KMOLE/S]
XSR1 = MOLAR FLOW RATE OF SECONDARY REACTANT 1, D2 (H2) [KMOLE/S]
XSR2 = MOLAR FLOW RATE OF SECONDARY REACTANT 2, HE [KMOLE/S]
XSR3 = MOLAR FLOW RATE OF SECONDARY REACTANT 3, N2 [KMOLE/S]
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

LASER DEVICE SECTION GENERAL NOTATION SCHEME

VARIABLES ARE DEFINED AS FOLLOWS:

A : AREA PER KMOLE/S OF PRIMARY FLOW [S-M2/KMOLE]
D : DIAMETER [M]
G : (GAMMA) SPECIFIC HEAT RATIO
M : MACH NUMBER
MW: MOLECULAR WEIGHT [KG/KMOLE]
P : PRESSURE [PA]
R : DENSITY [KG/M3]
RE: REYNOLDS NUMBER
T : TEMPERATURE [K]
W : MASS FLOW RATE [KG/S]
X : MOLAR FLOW RATE [KMOLE/S]

REPEATED LETTERS INDICATE RATIOS.
EXAMPLE: W6W2=W6/W2

VARIABLES ARE DESIGNATED AS TO LOCATION BY THE FOLLOWING:

POINT 1: PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE
POINT 2: PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE
POINT 3: SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE
POINT 4: SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE
POINT 5: EXIT OF THE CONSTANT-AREA MIXING REGION
POINT 6: EXIT OF THE ISENTROPIC EXPANSION REGION
POINT 7: MIRROR PURGE CONDITIONS
POINT 8: LASER CAVITY EXIT
EXAMPLE: MW8 = MOLECULAR WEIGHT AT THE CAVITY EXIT

E: INDICATES "EFFECTIVE" CONDITIONS
G: INDICATES "GEOMETRIC" CONDITIONS
S: INDICATES "*" CONDITIONS
0: INDICATES STAGNATION CONDITIONS
EXAMPLE: A1A1SG = A/A* AT THE PRIMARY NOZZLE EXIT BASED ON THE NOZZLE GEOMETRY

NOTE: ALL VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED IN THE NOMENCLATURE FOR THE PROGRAM OR SUBROUTINE WHERE THEY APPEAR.

NOMENCLATURE FOR PROGRAM LDS AND SUBROUTINES INLDS, OUTLDS

A = VISCOSITY COEFFICIENT (ALOG(N-S/M2)/ALOG(K))
B = VISCOSITY COEFFICIENT (ALOG(N-S/M2))
BRFRAC = NOZZLE BANK RELIEF FRACTION
CANGLE = LASER CAVITY HALF-ANGLE (RAD)
CCSS1 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW COMBUSTION CHEMISTRY INPUTS ARE REQUIRED
CHOKE = ALPHANUMERIC SYMBOL DESIGNATING CHOKED FLOW
DFORHF = CONTROL VARIABLE DESIGNATING DF OR HF LASER CHEMISTRY
FAIL = ERROR FLAG
FLOW = CHOKED/SEPARATED/SUBSONIC/SUPERSONIC FLOW FLAG
GEOMPN = PRIMARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:
= "AX" FOR AXISYMMETRIC NOZZLES
= "2D" FOR SLIT NOZZLES
GEOMSN = SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:
= "AX" FOR AXISYMMETRIC NOZZLES
= "2D" FOR SLIT NOZZLES
GP = SPECIFIC HEAT RATIO OF THE CAVITY PRODUCT MIXTURE WITHOUT MIRROR PURGE
HBASE = HEIGHT OF NOZZLE BASE (M)
HF = ALPHANUMERIC SYMBOL DESIGNATING HF LASER CHEMISTRY
HNB = HEIGHT OF NOZZLE BANK (M)
K = DO LOOP INDEX
LCAV = LASER CAVITY CENTER LINE LENGTH (M)
LDSS1 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW LASER DEVICE INPUTS ARE REQUIRED
LDSS2 = CONTROL VARIABLE DESIGNATING AN INPUT VARIABLE AS EITHER:
= "T10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE OR
= "P10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION PRESSURE
LDSS3 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT INPUT DATA SHOULD BE READ FROM TAPE2
LPNOZ = CENTER LINE LENGTH OF A PRIMARY NOZZLE FROM THROAT TO EXIT PLANE (M)
LSEP = CAVITY FLOW SEPARATION LENGTH FROM THE NOZZLE FACE (M)
LSLCAV = CAVITY FLOW SEPARATION LENGTH-TO-TOTAL CAVITY LENGTH RATIO
LSNOZ = CENTER LINE LENGTH OF A SECONDARY NOZZLE FROM THROAT TO EXIT PLANE (M)
MWP = MOLECULAR WEIGHT OF THE CAVITY PRODUCT MIXTURE WITHOUT MIRROR PURGE (KG/KMOLE)
MWPMW6 = CAVITY PRODUCT MIXTURE (WITHOUT MIRROR PURGE)-TO-ISENTROPIC EXPANSION REGION EXIT MOLECULAR WEIGHT RATIO
NO = ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NPNOZ = NUMBER OF PRIMARY NOZZLES PER KMOLE/S OF PRIMARY FLOW (S/KMOLE)
NSNOZ = NUMBER OF SECONDARY NOZZLES PER KMOLE/S OF PRIMARY FLOW (S/KMOLE)
NSPNOZ = NUMBER OF SECONDARY-TO-PRIMARY NOZZLES
PKFRAC = NOZZLE PACKING FRACTION
Q = HEAT RELEASED PER KMOLE OF PRIMARY COMBUSTOR FLOW BY THE CHEMICAL REACTION OF FLUORINE IN THE LASER CAVITY (J/KMOLE)
Q68 = DIMENSIONLESS HEAT RELEASE BETWEEN STATIONS 6 AND 8
RBAR = UNIVERSAL GAS CONSTANT (J/KMOLE-K)

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SETLDS    = CONTROL VARIABLE TO SET DEFAULT VALUES
SEP       = ALPHANUMERIC SYMBOL DESIGNATING SEPARATED FLOW
SUP       = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
TP        = ESTIMATED STATIC TEMPERATURE OF THE CAVITY PRODUCT MIXTURE
            WITHOUT MIRROR PURGE (K)
XF        = MOLE FRACTION ARRAY
XFCP1(1) = MOLE FRACTION OF CAVITY PRODUCT 1, CF4,    W/O MIRROR PURGE
     (2) = MOLE FRACTION OF CAVITY PRODUCT 1, CF4,    WITH MIRROR PURGE
XFCP2(1) = MOLE FRACTION OF CAVITY PRODUCT 2, HF,     W/O MIRROR PURGE
     (2) = MOLE FRACTION OF CAVITY PRODUCT 2, HF,     WITH MIRROR PURGE
XFCP3(1) = MOLE FRACTION OF CAVITY PRODUCT 3, DF,     W/O MIRROR PURGE
     (2) = MOLE FRACTION OF CAVITY PRODUCT 3, DF,     WITH MIRROR PURGE
XFCP4(1) = MOLE FRACTION OF CAVITY PRODUCT 4, HE,     W/O MIRROR PURGE
     (2) = MOLE FRACTION OF CAVITY PRODUCT 4, HE,     WITH MIRROR PURGE
XFCP5(1) = MOLE FRACTION OF CAVITY PRODUCT 5, N2,     W/O MIRROR PURGE
     (2) = MOLE FRACTION OF CAVITY PRODUCT 5, N2,     WITH MIRROR PURGE
XFCP6(1) = MOLE FRACTION OF CAVITY PRODUCT 6, D (H), W/O MIRROR PURGE
     (2) = MOLE FRACTION OF CAVITY PRODUCT 6, D (H), WITH MIRROR PURGE
YES       = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE
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NOMENCLATURE FOR SUBROUTINE CAMS

AS1AP1 = SECONDARY-TO-PRIMARY STREAM AREA RATIO
C1 = INTERMEDIATE CONSTANT
C2 = INTERMEDIATE CONSTANT
C3 = INTERMEDIATE CONSTANT
C4 = INTERMEDIATE CONSTANT
FAIL = ERROR FLAG
FFX = INTERMEDIATE CONSTANT
FLOW = SUBSONIC/SUPERSONIC FLOW FLAG
GM = MIXED STREAM SPECIFIC HEAT RATIO
GMGP = MIXED-TO-PRIMARY STREAM RATIO OF SPECIFIC HEAT RATIOS
GP = PRIMARY STREAM SPECIFIC HEAT RATIO
GP3 = INTERMEDIATE CONSTANT
GS = SECONDARY STREAM SPECIFIC HEAT RATIO
GSGP = SECONDARY-TO-PRIMARY STREAM RATIO OF SPECIFIC HEAT RATIOS
GS3 = INTERMEDIATE CONSTANT
MM3 = MIXED STREAM MACH NUMBER
MP1 = PRIMARY STREAM MACH NUMBER
MS1 = SECONDARY STREAM MACH NUMBER
MWMMWP = MIXED-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
MWPMWS = PRIMARY-TO-SECONDARY STREAM MOLECULAR WEIGHT RATIO
MWSMWP = SECONDARY-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
PM3PP1 = MIXED-TO-PRIMARY STREAM STATIC PRESSURE RATIO
PS1PP1 = SECONDARY-TO-PRIMARY STREAM STATIC PRESSURE RATIO
SUP = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
TM0TP0 = MIXED-TO-PRIMARY STREAM STAGNATION TEMPERATURE RATIO
TS0TP0 = SECONDARY-TO-PRIMARY STREAM STAGNATION TEMPERATURE RATIO
WSWP = SECONDARY-TO-PRIMARY STREAM MASS FLOW RATIO
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR SUBROUTINE CPCALC

CP = SPECIFIC HEAT DATA ARRAY (1.0E-04 J/KMOLE-K)
CPMIX = SPECIFIC HEAT OF THE GAS MIXTURE (J/KMOLE-K)
CPTDZ = SPECIFIC HEAT AT THE GAS MIXTURE TEMPERATURE (J/KMOLE-K)
FRAC = INTERPOLATION WEIGHTING FACTOR
GMIX = SPECIFIC HEAT RATIO OF THE GAS MIXTURE
I = DO LOOP INDEX
J = INTEGER FOR CP TABLE TEMPERATURE SELECTION
MW = MOLECULAR WEIGHT DATA ARRAY (KG/KMOLE)
MWMIX = MOLECULAR WEIGHT OF THE GAS MIXTURE (KG/KMOLE)
NS1 = DO LOOP LIMIT FOR SPECIES SELECTION
NS2 = DO LOOP LIMIT FOR SPECIES SELECTION
RBAR = UNIVERSAL GAS CONSTANT (J/KMOLE-K)
TDZ = TEMPERATURE OF THE GAS MIXTURE (K)
TLO = LOW OR TEMPERATURE FOR LINEAR INTERPOLATION (K)
XF = MOLE FRACTION ARRAY

NOMENCLATURE FOR SUBROUTINE EXPAN

A1A1S = A/A* FOR THE ENTERING STREAM
A2A1 = EXIT-TO-ENTRANCE AREA RATIO
FAIL = ERROR FLAG
G = SPECIFIC HEAT RATIO
G2 = INTERMEDIATE CONSTANT
G4 = INTERMEDIATE CONSTANT
M1 = ENTRANCE MACH NUMBER
M2 = EXIT MACH NUMBER
P2P1 = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO
P20P10 = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO
SUP = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
T2T1 = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO
T20T10 = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR SUBROUTINE ITER

DX = STEP SIZE FOR CHANGING THE INDEPENDENT VARIABLE, X, IN THE INCREMENT MODE
ERRORX = MAXIMUM PERCENT DEVIATION IN THE CURRENT AND PREVIOUS VALUE OF X FOR A SOLUTION
ERRORY = MAXIMUM PERCENT ERROR IN Y AND YGIVEN FOR A SOLUTION
NIT = ITERATION NUMBER
NSIGN = INTERMEDIATE CONSTANT
NSIGN1 = INTERMEDIATE CONSTANT
NSIGN2 = INTERMEDIATE CONSTANT
NTYPE = CONTROL VARIABLE SUCH THAT:
= 1, FOR THE INCREMENT MODE
= 2, FOR THE INTERPOLATION MODE
= 3, FOR A SOLUTION
RATIO = INTERPOLATION WEIGHTING FACTOR
SIGN = CONTROL VARIABLE FOR THE DIRECTION OF INCREMENT FROM THE INITIAL VALUE OF X
X = INDEPENDENT VARIABLE
XNEG = PREVIOUS VALUE OF X
XPOS = PREVIOUS VALUE OF X
XSAVE = PREVIOUS VALUE OF X
Y = DEPENDENT VARIABLE
YGIVEN = GIVEN VALUE OF THE DEPENDENT VARIABLE
YNEG = PREVIOUS VALUE OF Y
YPOS = PREVIOUS VALUE OF Y

NOMENCLATURE FOR SUBROUTINE LBLAYR

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A      = SLOPE OF VISCOSITY-TEMPERATURE RELATION (ALOG(N-S/M2)/ALOG(K))
B      = INTERSECT OF VISCOSITY-TEMPERATURE RELATION (ALOG(N-S/M2))
DELTA  = BOUDARY LAYER THICKNESS (M)
GEOFAC = NOZZLE GEOMETRY FACTOR SUCH THAT:
       = 1.0, FOR AXISYMMETRIC NOZZLES
       = 0.0, FOR SLIT NOZZLES
LBNOZ  = NOZZLE BOUNDARY LAYER LENGTH (M)
MU     = ABSOLUTE VISCOSITY (N-S/M2)
MW     = MOLECULAR WEIGHT (KG/KMOLE)
PE     = STATIC PRESSURE AT THE NOZZLE EXIT (PA)
RBAR   = UNIVERSAL GAS CONSTANT (J/KMOLE-K)
RE     = REYNOLDS NUMBER AT THE NOZZLE EXIT
T      = ADIABATIC WALL TEMPERATURE (K)
TE     = STATIC TEMPERATURE AT THE NOZZLE EXIT (K)
T0     = NOZZLE STAGNATION TEMPERATURE (K)
VE     = VELOCITY AT THE NOZZLE EXIT (M/S)
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NOMENCLATURE FOR SUBROUTINES LCAS, LCFS

A2A1 = EXIT-TO-ENTRANCE AREA RATIO
CHOKE = ALPHANUMERIC SYMBOL DESIGNATING CHOKED FLOW
C1 = INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
C2 = INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
C3 = INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
C4 = INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
DUM1 = DUMMY VARIABLE
DUM2 = DUMMY VARIABLE
DZ = STEP SIZE FOR THE SIMPSON'S RULE INTEGRATION
DZRKI = STEP SIZE FOR THE RUNGE-KUTTA INTEGRATION
D1 = INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
D2 = INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
D3 = INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
D4 = INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
FA = AREA FUNCTION
FGM = SPECIFIC HEAT RATIO FUNCTION
FH = ENTHALPY FUNCTION
FLOW = CHOKED/SEPARATED FLOW FLAG
FMSQ = MACH NUMBER FUNCTION
FMWM = MOLECULAR WEIGHT FUNCTION
FP = STATIC PRESSURE FUNCTION
FTM = STATIC TEMPERATURE FUNCTION
FXM = MOLAR FLOW RATE FUNCTION
F1 = FUNCTION OF Z
F2 = FUNCTION OF Z
F3 = FUNCTION OF Z
GA = SPECIFIC HEAT RATIO OF THE PURGE GAS
GA1 = INTERMEDIATE CONSTANT
GA2 = INTERMEDIATE CONSTANT
GM = SPECIFIC HEAT RATIO OF THE MIXED STREAM
GP = SPECIFIC HEAT RATIO OF THE PRODUCT GAS
GP1 = INTERMEDIATE CONSTANT
GP2 = INTERMEDIATE CONSTANT
GR = SPECIFIC HEAT RATIO OF THE REACTANT GAS
GR1 = INTERMEDIATE CONSTANT
GR2 = INTERMEDIATE CONSTANT
I = DO LOOP INDEX
J = DO LOOP INDEX
K = DO LOOP INDEX
LPMPR1 = NATURAL LOG OF THE LOCAL MIXED-TO-REACTANT STATIC PRESSURE RATIO
M1 = INITIAL MACH NUMBER FOR A ZUKOSKI SEPARATION CRITERIA
MM2 = MACH NUMBER OF THE MIXED STREAM AT THE CAVITY EXIT
MSQ = SQUARE OF THE MACH NUMBER
MWAMWR = PURGE-TO-REACTANT MOLECULAR WEIGHT RATIO
MWMMWR = MIXED-TO-REACTANT MOLECULAR WEIGHT RATIO
MWPMWR = PRODUCT-TO-REACTANT MOLECULAR WEIGHT RATIO
MWRMWA = REACTANT-TO-PURGE MOLECULAR WEIGHT RATIO
MWRMWP = REACTANT-TO-PRODUCT MOLECULAR WEIGHT RATIO
N = COMPUTE GO TO STATEMENT INDEX
NPTS = NUMBER OF POINTS FOR THE SIMPSON'S RULE INTEGRATION
PMPI = LOCAL MIXED-TO-INITIAL STATIC PRESSURE RATIO

OVERLAY LDS

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PM0PR0 = MIXED-TO-REACTANT STAGNATION PRESSURE RATIO
PM2PR1 = FINAL MIXED-TO-REACTANT STATIC PRESSURE RATIO
PR1PI  = REACTANT-TO-INITIAL STATIC PRESSURE RATIO
PSEPPI = ZUKOSKI SEPARATION-TO-INITIAL STATIC PRESSURE RATIO
Q      = LOCAL DIMENSIONLESS HEAT RELEASE
Q1     = HEAT RELEASE COEFFICIENT
Q12    = DIMENSIONLESS HEAT RELEASE
Q2     = HEAT RELEASE COEFFICIENT
SEP    = ALPHANUMERIC SYMBOL DESIGNATING SEPARATED FLOW
TA0TR1 = PURGE STAGNATION-TO-REACTANT STATIC TEMPERATURE RATIO
TMTR1  = LOCAL MIXED-TO-REACTANT STATIC TEMPERATURE RATIO
TM0TR0 = MIXED-TO-REACTANT STAGNATION TEMPERATURE RATIO
TM2TR1 = FINAL MIXED-TO-REACTANT STATIC TEMPERATURE RATIO
WA2WR1 = PURGE-TO-REACTANT MASS FLOW RATIO
XMXR1  = LOCAL MIXED-TO-REACTANT MOLAR FLOW RATIO
XM2XR1 = FINAL MIXED-TO-REACTANT MOLAR FLOW RATIO
Z      = DIMENSIONLESS AXIAL COORDINATE
ZSEP   = DIMENSIONLESS CAVITY FLOW SEPARATION LENGTH
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NOMENCLATURE FOR SUBROUTINES LPNCS, LSNCS1, LSNCS2

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A       = VISCOSITY COEFFIECIENT [ALOG(N-S/M2)/ALOG(K)]
AEASE   = A/A*, EFFECTIVE
AEASG   = A/A*, GEOMETRIC
AEF     = EFFECTIVE NOZZLE EXIT AREA [M2]
AFAC    = AREA FACTOR [M2]
AKMSC   = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW PER KMOLE/S
          OF PRIMARY FLOW BASED ON THE COMBUSTOR TEMPERATURE [S-M2/KMOLE]
AKMSE   = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW PER KMOLE/S
          OF PRIMARY FLOW BASED ON THE EXIT TEMPERATURE [S-M2/KMOLE]
AKMST   = TOTAL AREA OF NOZZLE BANK PER KMOLE/S OF PRIMARY FLOW BASED ON
          THE EXIT TEMPERATURE [S-M2/KMOLE]
AS      = A* [M2]
AX      = ALPHANUMERIC SYMBOL DESIGNATING AN AXISYMMETRIC NOZZLE
B       = VISCOSITY COEFFIECENT [ALOG(N-S/M2)]
C1      = INTERMEDIATE CONSTANT
C2      = INTERMEDIATE CONSTANT
C3      = INTERMEDIATE CONSTANT
C4      = INTERMEDIATE CONSTANT
C5      = INTERMEDIATE CONSTANT
C6      = INTERMEDIATE CONSTANT
C7      = INTERMEDIATE CONSTANT
DE      = NOZZLE EXIT DIAMETER, GEOMETRIC [M]
DEE     = NOZZLE EXIT DIAMETER, EFFECTIVE [M]
DELME   = INCREMENT IN EXIT MACH NUMBER FOR SUBROUTINE ITER
DELTA   = BOUNDARY LAYER THICKNESS AT THE NOZZLE EXIT [M]
DFORHF  = CONTROL VARIABLE DESIGNATING DF OR HF LASER CHEMISTRY
DPE     = PRIMARY NOZZLE EXIT DIAMETER, GEOMETRIC [M]
DPEE    = PRIMARY NOZZLE EXIT DIAMETER, EFFECTIVE [M]
DPS     = D*, PRIMARY NOZZLE [M]
DS      = D* [M]
DSE     = SECONDARY NOZZLE EXIT DIAMETER, GEOMETRIC [M]
DUMMY   = DUMMY VARIABLE
ERROR   = SOLUTION TOLERANCE
F       = LENGTH MEAN COEFFICIENT OF FRICTION
FAIL    = ERROR FLAG
FDAA    = FREE FLUORINE FLUX [KMOLE/S-M2]
FFLD    = 4*F*L/D
FX      = PREVIOUS VALUE OF F IN ITERATION SCHEME
GC      = SPECIFIC HEAT RATIO OF THE NOZZLE STREAM BASED ON THE COMBUSTOR
          OR NOZZLE STAGNATION TEMPERATURE
GE      = SPECIFIC HEAT RATIO OF THE NOZZLE STREAM BASED ON THE NOZZLE
          EXIT TEMPERATURE
GEOFAC  = NOZZLE GEOMETRY FACTOR SUCH THAT:
        = 1.0, FOR AXISYMMETRIC NOZZLES
        = 0.0, FOR SLIT NOZZLES
GEOMPN  = PRIMARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:
        = "AX", FOR AXISYMMETRIC NOZZLES
        = "2D", FOR SLIT NOZZLES
GEOMSN  = SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:
        = "AX", FOR AXISYMMETRIC NOZZLES
        = "2D", FOR SLIT NOZZLES
H       = INTERMEDIATE CONSTANT
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HF = ALPHANUMERIC SYMBOL DESIGNATING HF LASER CHEMISTRY
HNB = HEIGHT OF NOZZLE BANK [M]
HP = INTERMEDIATE CONSTANT
HYDIA = HYDRAULIC DIAMETER
I = DO LOOP INDEX
ITER1 = DO LOOP INDEX
LBNOZ = NOZZLE BOUNDARY LAYER LENGTH [M]
LOSS2 = CONTROL VARIABLE DESIGNATING AN INPUT VARIABLE AS EITHER:
= "T10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE OR
= "P10" FOR THE PRIMARY NOZZLE STAGNATION PRESSURE
LPNOZ = CENTER LINE LENGTH OF A PRIMARY NOZZLE FROM THROAT TO EXIT PLANE [M]
LSNOZ = CENTER LINE LENGTH OF A SECONDARY NOZZLE FROM THROAT TO EXIT PLANE [M]
ME = NOZZLE EXIT MACH NUMBER
MSUPD = NOZZLE SUPERSONIC DESIGN MACH NUMBER
MU = ABSOLUTE VISCOSITY [N-S/M2]
MW = MOLECULAR WEIGHT [KG/KMOLE]
M2 = SQUARE OF THE MACH NUMBER
NIT = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NPNOZ = NUMBER OF PRIMARY NOZZLES PER KMOLE/S OF PRIMARY FLOW [S/KMOLE]
NSIGN1 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSIGN2 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSNOZ = NUMBER OF SECONDARY NOZZLES PER KMOLE/S OF PRIMARY FLOW [S/KMOLE]
NSPNOZ = NUMBER OF SECONDARY-TO-PRIMARY NOZZLES
NTYPE = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
PE = STATIC PRESSURE AT THE NOZZLE EXIT [PA]
PI = THE CONSTANT PI
PKFRAC = NOZZLE PACKING FRACTION
PS = P*, STATIC PRESSURE FOR A MACH NUMER OF ONE [PA]
P0 = COMBUSTOR OR NOZZLE STAGNATION PRESSURE [PA]
P0P0S = THE STAGNATION PRESSURE RATIO, P0/P0*
P0S = P0*, STAGNATION PRESSURE FOR A MACH NUMBER OF ONE [PA]
RBAR = UNIVERSAL GAS CONSTANT [J/KMOLE-K]
RE = REYNOLDS NUMBER AT THE NOZZLE EXIT
RL = MOLAR CAVITY MIXTURE RATIO
SIGMA = DEPENDENT VARIABLE FOR SUBROUTINE ITER
SUP = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
TE = STATIC TEMPERATURE AT THE NOZZLE EXIT [K]
T0 = COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE [K]
VE = VELOCITY AT THE NOZZLE EXIT [M/S]
WP = PRIMARY NOZZLE MASS FLOW RATE [KG/S]
WS = SECONDARY NOZZLE MASS FLOW RATE [KG/S]
XAEASE = PREVIOUS VALUE OF AEASE IN ITERATION SCHEME
XF = MOLE FRACTION ARRAY
XFPP1 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 1, CF4
XFPP2 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 2, F2
XFPP3 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 3, F
XFPP4 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF)
XFPP5 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 5, HE
XFPP6 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 6, N2
XFSR1 = MOLE FRACTION OF SECONDARY REACTANT 1, D2 (H2)
XFSR2 = MOLE FRACTION OF SECONDARY REACTANT 2, HE

OVERLAY LDS

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XFSR3   = MOLE FRACTION OF SECONDARY REACTANT 3, N2
XKMS    = TOTAL SECONDARY MOLAR FLOW RATE PER KMOLE/S OF PRIMARY FLOW
XM2     = PREVIOUS VALUE OF M2 IN ITERATION SCHEME
XNEG    = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
[illegible] = PRIMARY NOZZLE MOLAR FLOW RATE (KMOLE/S)
XPOS    = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XS      = SECONDARY NOZZLE MOLAR FLOW RATE (KMOLE/S)
YES     = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE
YNEG    = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
YPOS    = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
```

NOMENCLATURE FOR SUBROUTINE MAAS

ERROR = MAXIMUM PERCENT DEVIATION IN MOLD AND MNEW FOR A SOLUTION
FAIL = ERROR FLAG
FLOW = CONTROL VARIABLE SUCH THAT:
= "SUB" FOR THE SUBSONIC BRANCH
= "SUP" FOR THE SUPERSONIC BRANCH
G = SPECIFIC HEAT RATIO
G1 = INTERMEDIATE CONSTANT
G1I = INTERMEDIATE CONSTANT
G2 = INTERMEDIATE CONSTANT
G2I = INTERMEDIATE CONSTANT
G4 = INTERMEDIATE CONSTANT
G4I = INTERMEDIATE CONSTANT
J = DO LOOP INDEX
MINI = INITIAL VALUE OF MACH NUMBER
MNEW = CURRENT VALUE OF MACH NUMBER
MOLD = PRECEEDING VALUE OF MACH NUMBER
SUP = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
XERROR = CURRENT PERCENT DEVIATION IN MOLD AND MNEW
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR SUBROUTINE VISC

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A       = VISCOSITY COEFFICIENT [ALOG(N-S/M2)/ALOG(K)]
B       = VISCOSITY COEFFICIENT [ALOG(N-S/M2)]
C       = INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
DEN     = INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
DIV     = INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
I       = DO LOOP INDEX
J       = DO LOOP INDEX
K       = DO LOOP INDEX
MU      = VISCOSITY DATA ARRAY [1.0E+07 N-S/M2]
MUMIX   = VISCOSITY OF THE GAS MIXTURE [N-S/M2]
MW      = MOLECULAR WEIGHT DATA ARRAY [KG/KMOLE]
NS1     = DO LOOP LIMIT FOR SPECIES SELECTION
NS2     = DO LOOP LIMIT FOR SPECIES SELECTION
NUM     = INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
PHI     = INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
R1      = INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
R2      = INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
SUMI    = INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
SUMJ    = INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
SX      = INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
SXY     = INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
SX2     = INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
SY      = INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
T       = TEMPERATURE OF THE GAS MIXTURE [K]
X       = INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
XF      = MOLE FRACTION ARRAY
Y       = INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
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PRESSURE RECOVERY SECTION GENERAL NOTATION SCHEME

A : AREA PER KMOLE/S OF LASER PRIMARY FLOW [S-M2/KMOLE]
G : (GAMMA) SPECIFIC HEAT RATIO
M : MACH NUMBER
MW: MOLECULAR WEIGHT [KG/KMOLE]
P : PRESSURE [PA]
R : DENSITY [KG/M3]
T : TEMPERATURE [K]
W : MASS FLOW RATE [KG/S]
X : MOLAR FLOW RATE [KMOLE/S]

REPEATED LETTERS INDICATE RATIOS.
EXAMPLE: A2A1 = A2/A1

VARIABLES ARE DESIGNATED AS TO LOCATION BY THE FOLLOWING:

POINT 1: LASER CAVITY EXIT
POINT 2: NORMAL SHOCK DIFFUSER EXIT
POINT 3: SUBSONIC DIFFUSER EXIT
POINT 4: EJECTOR SECONDARY NOZZLE EXIT
POINT 5: EJECTOR PRIMARY NOZZLE EXIT
POINT 6: EJECTOR MIXING TUBE EXIT
POINT 7: SUBSONIC DIFFUSER EXIT
EXAMPLE: M5 = EJECTOR PRIMARY NOZZLE EXIT MACH NUMBER

0: INDICATES STAGNATION CONDITIONS
EXAMPLE: T20 = NORMAL SHOCK DIFFUSER EXIT STAGNATION TEMPERATURE

NOTE: ALL VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED IN THE NOMENCLATURE FOR THE PROGRAM OR SUBROUTINE WHERE THEY APPEAR.

NOMENCLATURE FOR PROGRAM PRS AND SUBROUTINES CAEOS,INPRS,OUTPRS,SSEOS

CAE = ALPHANUMERIC SYMBOL DESIGNATING A SUBSONIC-SUPERSONIC EJECTOR FOR PRESSURE RECOVERY
EJECT = CONTROL VARIABLE DESIGNATING THE PRESSURE RECOVERY SYSTEM SUCH THAT:
= "NO" FOR NO PRESSURE RECOVERY SYSTEM
= "DIF" FOR A SUPERSONIC-SUBSONIC DIFFUSED SYSTEM
= "CAE" FOR A CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SYSTEM
= "SSE" FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR SYSTEM
ETA12 = NORMAL SHOCK DIFFUSER COEFFICIENT FOR THE FLOW BETWEEN STATIONS 1 AND 2
ETA23 = SUBSONIC DIFFUSER COEFFICIENT FOR THE FLOW BETWEEN STATIONS 2 AND 3
ETA67 = SUBSONIC DIFFUSER COEFFICIENT FOR THE FLOW BETWEEN STATIONS 6 AND 7
FAIL = ERROR FLAG
GM = EJECTOR MIXED STREAM SPECIFIC HEAT RATIO
GP = EJECTOR PRIMARY STREAM SPECIFIC HEAT RATIO
GS = EJECTOR SECONDARY STREAM SPECIFIC HEAT RATIO
ITER1 = DO LOOP INDEX
ITER2 = DO LOOP INDEX
ITER3 = DO LOOP INDEX
K = DO LOOP INDEX
LDSS1 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW LASER DEVICE INPUTS ARE REQUIRED
LIMIT = CONTROL VARIABLE TO SET THE LIMITING CONDITION ON CONSANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR OPERATION SUCH THAT:
= "MPP" FOR THE MATCHED PRESSURE POINT
= "ZSP" FOR THE ZUKOSKI SEPARATION POINT
= "ULP" FOR THE UPPER LIMIT POINT
MPP = ALPHANUMERIC SYMBOL DESIGNATING THE MATCHED PRESSURE POINT
MWMMWP = EJECTOR MIXED-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
MWPMWS = EJECTOR PRIMARY-TO-SECONDARY STREAM MOLECULAR WEIGHT RATIO
MWSMWP = EJECTOR SECONDARY-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
NIT1 = INTERMEDIATE CONSTANT FOR SUBROUTINE MIN
NIT2 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NIT3 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NO = ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NSIGN1 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSIGN2 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSIGN3 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSIGN4 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NTYPE1 = INTERMEDIATE CONSTANT FOR SUBROUTINE MIN
NTYPE2 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NTYPE3 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
PDPU = DISTURBED-TO-UNDISTURBED STATIC PRESSURE RATIO
PRSS1 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW PRESSURE RECOVERY INPUTS ARE REQUIRED
PRSS2 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT INPUT DATA SHOULD BE READ FROM TAPE3
RBAR = UNIVERSAL GAS CONSTANT [J/KMOLE-K]
SETPRS = CONTROL VARIABLE TO SET DEFAULT VALUES

SSE = ALPHANUMERIC SYMBOL DESIGNATING A SUPERSONIC-SUPERSONIC EJECTOR FOR PRESSURE RECOVERY
ULP = ALPHANUMERIC SYMBOL DESIGNATING THE UPPER LIMIT POINT
WPWS = EJECTOR PRIMARY-TO-SECONDARY MASS FLOW RATIO
WSWP = EJECTOR SECONDARY-TO-PRIMARY MASS FLOW RATIO
XNEG2 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XNEG3 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XPOS2 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XPOS3 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XP50P1 = PREVIOUS VALUE OF P50P1 IN ITERATION SCHEME
XP50P40 = PREVIOUS VALUE OF P50P40 IN ITERATION SCHEME
XP7P1 = PREVIOUS VALUE OF P7P1 IN ITERATION SCHEME
XP7P40 = PREVIOUS VALUE OF P7P40 IN ITERATION SCHEME
XWPWS = PREVIOUS VALUE OF WPWS IN ITERATION SCHEME
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE
YNEG2 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
YNEG3 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
YPOS2 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
YPOS3 = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
ZSP = ALPHANUMERIC SYMBOL DESIGNATING A ZUKOSKI SEPARATION POINT

NOMENCLATURE FOR SUBROUTINES CAEFC, CAEOCV, SSES

AP1AM3 = ENTRANCE PRIMARY-TO-EXIT MIXED STREAM AREA RATIO
AP1APS = A/A* FOR THE ENTERING PRIMARY STREAM
AP2APS = A/A* FOR THE PRIMARY STREAM AT THE MINIMUM POINT
ASSAS1 = A*/A FOR THE ENTERING SECONDARY STREAM
AS1AP1 = ENTERING SECONDARY-TO-PRIMARY STREAM AREA RATIO
AS1ASS = A/A* FOR THE ENTERING SECONDARY STREAM
AS2ASS = A/A* FOR THE SECONDARY STREAM AT THE MINIMUM POINT
AS2AS1 = MINIMUM POINT-TO-ENTERING AREA RATIO FOR THE SECONDARY STREAM
CPSCPP = SECONDARY-TO-PRIMARY STREAM SPECIFIC HEAT RATIO
C0 = INTERMEDIATE CONSTANT
C1 = INTERMEDIATE CONSTANT
C2 = INTERMEDIATE CONSTANT
C3 = INTERMEDIATE CONSTANT
C4 = INTERMEDIATE CONSTANT
C5 = INTERMEDIATE CONSTANT
C6 = INTERMEDIATE CONSTANT
FAIL = ERROR FLAG
FFX = INTERMEDIATE CONSTANT
FGPMP1 = INTERMEDIATE CONSTANT
FGSMS1 = INTERMEDIATE CONSTANT
FLOW = SUBSONIC/SUPERSONIC FLOW FLAG
GGPMP1 = INTERMEDIATE CONSTANT
GGSMS1 = INTERMEDIATE CONSTANT
GM = MIXED STREAM SPECIFIC HEAT RATIO
GMGP = MIXED-TO-PRIMARY STREAM RATIO OF SPECIFIC HEAT RATIOS
GP = PRIMARY STREAM SPECIFIC HEAT RATIO
GP3 = INTERMEDIATE CONSTANT
GS = SECONDARY STREAM SPECIFIC HEAT RATIO
GSGP = SECONDARY-TO-PRIMARY STREAM RATIO OF SPECIFIC HEAT RATIOS
GS3 = INTERMEDIATE CONSTANT
LIMIT = CONTROL VARIABLE TO SET THE LIMITING CONDITION ON CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR OPERATION SUCH THAT:
= "MPP" FOR THE MATCHED PRESSURE POINT
= "ZSP" FOR THE ZUKOSKI SEPARATION POINT
= "ULP" FOR THE UPPER LIMIT POINT
MM3 = EXITING MIXED STREAM MACH NUMBER
MM3M = ONE OF TWO POSSIBLE SOLUTIONS FOR MM3
MM3P = ONE OF TWO POSSIBLE SOLUTIONS FOR MM3
MPP = ALPHANUMERIC SYMBOL DESIGNATING THE MATCHED PRESSURE POINT
MP1 = ENTERING PRIMARY STREAM MACH NUMBER
MP2 = PRIMARY STREAM MACH NUMBER AT THE MINIMUM POINT
MSQD3M = THE SQUARE OF MM3M
MSQD3P = THE SQUARE OF MM3P
MS1 = ENTERING SECONDARY STREAM MACH NUMBER
MS2 = SECONDARY STREAM MACH NUMBER AT THE MINIMUM POINT
MWMMWP = MIXED-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
MWPMWS = PRIMARY-TO-SECONDARY STREAM MOLECULAR WEIGHT RATIO
MWSMWP = SECONDARY-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
PART = ALPHANUMERIC SYMBOL DESIGNATING NON-FATAL OR PARTIAL ERROR
PM3PP1 = EXITING MIXED-TO-ENTERING PRIMARY STATIC PRESSURE RATIO
PM3PS0 = EXITING MIXED STATIC-TO-ENTERING SECONDARY STAGNATION PRESSURE RATIO

PM3PS1 = EXITING MIXED-TO-ENTERING SECONDARY STATIC PRESSURE RATIO
PP0PS0 = ENTERING PRIMARY-TO-SECONDARY STAGNATION PRESSURE RATIO
PP0PS1 = ENTERING PRIMARY STAGNATION-TO-SECONDARY STATIC PRESSURE RATIO
PS1PP0 = ENTERING SECONDARY STATIC-TO-PRIMARY STAGNATION PRESSURE RATIO
PS1PP1 = ENTERING SECONDARY-TO-PRIMARY STATIC PRESSURE RATIO
PS1PS0 = ENTERING SECONDARY STATIC-TO-STAGNATION PRESSURE RATIO
PS2PS0 = STATIC-TO-STAGNATION PRESSURE RATIO FOR THE SECONDARY STREAM AT THE MINIMUM POINT
PS2PS1 = MINIMUM POINT-TO-ENTERING SECONDARY STREAM STATIC PRESSURE RATIO
SUP = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
TM0TP0 = MIXED-TO-PRIMARY STAGNATION TEMPERATURE RATIO
TM3 = INTERMEDIATE CONSTANT
TM3MIN = INTERMEDIATE CONSTANT
TS0TP0 = SECONDARY-TO-PRIMARY STAGNATION TEMPERATURE RATIO
ULP = ALPHANUMERIC SYMBOL DESIGNATING THE UPPER LIMIT POINT
VD = INTERMEDIATE CONSTANT
VN = INTERMEDIATE CONSTANT
WSWP = SECONDARY-TO-PRIMARY STREAM MASS FLOW RATIO
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR SUBROUTINE ITER

SEE THE NOMENCLATURE FOR SUBROUTINE ITER LISTED UNDER OVERLAY LDS.

NOMENCLATURE FOR SUBROUTINE MAAS

SEE THE NOMENCLATURE FOR SUBROUTINE MAAS LISTED UNDER OVERLAY LDS.

NOMENCLATURE FOR SUBROUTINE MIN

DMS1 = INCREMENT IN MS1
DX = INITIAL INCREMENT IN MS1
FAIL = ERROR FLAG
FUNC = FUNTION OF MS1 TO BE MINIMIZED
MS1 = SECONDARY MACH NUMBER AT THE MIXING TUBE ENTRANCE
MS1LOW = LOWER BOUND ON MS1
NIT = NUMBER OF ITERATIONS
NO = ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NTYPE = CONTROL VARIABLE SUCH THAT:
= 1,2 FOR THE SEARCH MODE
= 3,4 FOR A SOLUTION
PART = ALPHANUMERIC SYMBOL DESIGNATING A NON-FATAL OR PARTIAL ERROR
XERROR = MAXIMUM PERCENT DEVIATION IN THE CURRENT AND PREVIOUS VALUE OF MS1 FOR A SOLUTION
XLOW = INITIAL LOWER BOUND ON MS1
X1 = PREVIOUS VALUE OF MS1
X2 = PREVIOUS VALUE OF MS1
YERROR = MAXIMUM PERCENT DEVIATION IN THE CURRENT AND PREVIOUS VALUE OF FUNC FOR A SOLUTION
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE
Y1 = PREVIOUS VALUE OF FUNC
Y2 = PREVIOUS VALUE OF FUNC

NOMENCLATURE FOR SUBROUTINES NSDS, SDS

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A1A1S   = A/A* FOR THE ENTERING STREAM
A2A1    = EXIT-TO-ENTRANCE AREA RATIO
A2A2S   = A/A* FOR THE EXITING STREAM
EFF     = SUBSONIC DIFFUSER EFFICIENCY
FAIL    = ERROR FLAG
G       = SPECFIC HEAT RATIO
G2      = INTERMEDIATE CONSTANT
G4      = INTERMEDIATE CONSTANT
M1      = ENTRANCE MACH NUMBER
M2      = EXIT MACH NUMBER
P10P1   = ENTRANCE STAGNATION-TO-STATIC PRESSURE RATIO
P2P1    = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO
P20P10  = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO
P20P2   = EXIT STAGNATION-TO-STATIC PRESSURE RATIO
RD      = DIFFUSER COEFFIECIENT
SUB     = ALPHANUMERIC SYMBOL DESIGNATING SUBSONIC FLOW
T10T1   = ENTRANCE STAGNATION-TO-STATIC TEMPERATURE RATIO
T2T1    = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO
T20T10  = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO
T20T2   = EXIT STAGNATION-TO-STATIC TEMPERATURE RATIO
YES     = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE
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NOMENCLATURE FOR PROGRAM SCS AND SUBROUTINES INSCS, OUTSCS

ABASE = AREA OF A NOZZLE BASE (M2) - INCLUDES THE NOZZLE BANK AREA PLUS BANK RELIEF
ACONE = EXIT AREA OF AN EJECTOR PRIMARY NOZZLE CONE (M2)
AE = AREA AT STATION E (M2), THE EJECTOR, CONSTANT-AREA, MIXING SHROUD
AEPNE = TOTAL AREA OF THE EJECTOR PRIMARY NOZZLE EXITS PER KMOLE/S OF LASER PRIMARY FLOW (S-M2/KMOLE)
AESHRD = TOTAL AREA OF THE EJECTOR, CONSTANT-AREA, MIXING SHROUDS PER KMOLE/S OF LASER PRIMARY FLOW (S-M2/KMOLE)
ANB = AREA OF A NOZZLE BANK (M2)
ASCAV = SURFACE AREA OF A LASER CAVITY (M2)
ASCONE = SURFACE AREA OF AN EJECTOR PRIMARY NOZZLE CONE (M2)
ASPLEN = SURFACE AREA OF AN EJECTOR PRIMARY NOZZLE PLENNUM (M2)
ASSHRD = SURFACE AREA OF AN EJECTOR MIXING SHROUD (M2) - INCLUDES THE FINAL SUBSONIC DIFFUSER
ASSTRT = SURFACE AREA OF AN EJECTOR PRIMARY NOZZLE STRUT (M2)
ASSUBD = SURFACE AREA OF A SUBSONIC DIFFUSER (M2)
ASSUPD = SURFACE AREA OF A SUPERSONIC DIFFUSER (M2)
ASTAR = A* FOR AN EJECTOR PRIMARY NOZZLE (M2)
ASTR = SURFACE AREA OF AN EJECTOR TRANSITION PIECE (M2)
B = OPTICAL BENCH DIAMETER (M)
= INTERMEDIATE CONSTANT
BRFRAC = BANK RELIEF FRACTION
C = INTERMEDIATE CONSTANT
CAF = ALPHANUMERIC SYMBOL DESIGNATING A SUBSONIC-SUPERSONIC EJECTOR FOR PRESSURE RECOVERY
CANGLE = LASER CAVITY HALF-ANGLE (RAD)
DA = DIAMETER AT STATION A (M), THE LASER CAVITY EXIT
DB = DIAMETER AT STATION B (M), THE SUBSONIC DIFFUSER EXIT
DC = DIAMETER AT STATION C (M), THE INITIAL TRANSITION SECTION EXIT
DD = DIAMETER AT STATION D (M), THE FINAL TRANSITION SECTION EXIT
DE = DIAMETER AT STATION E (M), THE EJECTOR, CONSTANT-AREA, MIXING SHROUD
DESCRI = ARRAY OF ALPHANUMERIC STORAGE MODE DESCRIPTORS FOR I/O
DF = ALPHANUMERIC SYMBOL DESIGNATING OF LASER CHEMISTRY
= DIAMETER AT STATION F (M), THE EJECTOR SUBSONIC-DIFFUSER EXIT
DFORHF = CONTROL VARIABLE DESIGNATING DF OR HF LASER CHEMISTRY
DIF = ALPHANUMERIC SYMBOL DESIGNATING A SUPERSONIC-SUBSONIC DIFFUSER FOR PRESSURE RECOVERY
DL = DIAMETER AT STATION L (M), THE MAXIMUM DIAMETER OF A SUBSONIC-SUPERSONIC EJECTOR SHROUD
DMAX = INTERMEDIATE CONSTANT
DMIR = MIRROR DIAMETER (M)
DPLEN = DIAMETER OF AN EJECTOR PRIMARY NOZZLE PLENNUM (M)
DSTAR = D* FOR AN EJECTOR PRIMARY NOZZLE (M)
DSTRUT = DIAMETER OF AN EJECTOR PRIMARY NOZZLE STRUT (M)
EJECT = CONTROL VARIABLE DESIGNATING THE PRESSURE RECOVERY SYSTEM
ERFACT = CONTROL VARIABLE DESIGNATING THE EJECTOR PRIMARY REACTANT
FAIL = ERROR FLAG
FDAA = FREE FLUORINE FLUX (KMOLE/S-M2)
GEP = GAMMA, SPECIFIC HEAT RATIO, FOR THE EJECTOR PRIMARY REACTANT
HBASE = HEIGHT OF A NOZZLE BASE (M)

OVERLAY SCS

```
HBXDEV   = HEIGHT OF THE BOX DEVICE (M)
HF       = ALPHANUMERIC SYMBOL DESIGNATING HF LASER CHEMISTRY
HNB      = HEIGHT OF A NOZZLE BANK (M)
I        = DO LOOP INDEX
J        = DO LOOP INDEX
K        = STORAGE MODE CONTROL ARRAY
L        = DO LOOP INDEX
LBXDEV   = LENGTH OF THE BOX DEVICE (M)
LCAV     = LENGTH OF A LASER CAVITY (M)
LCOMB    = LENGTH OF A COMBUSTOR (M) - INCLUDES THE INJECTOR AND NOZZLE
           BANK
LCONE    = LENGTH OF AN EJECTOR PRIMARY NOZZLE CONE (M)
LEJECT   = LENGTH OF AN EJECTOR (M)
LINJ     = LENGTH OF AN INJECTOR (M)
LLDS     = LENGTH OF THE LASER DEVICE SECTION (M)
LLINE    = LENGTH OF REACTANT FEED LINES (M)
LPRS     = LENGTH OF THE PRESSURE RECOVERY SYSTEM (M)
LSUBD    = LENGTH OF A SUBSONIC DIFFUSER (M)
LSUPD    = LENGTH OF A SUPERSONIC DIFFUSER (M)
LTR1     = LENGTH OF AN INITIAL TRANSITION SECTION (M)
LTR2     = LENGTH OF A FINAL TRANSITION SECTION (M)
MAW      = TOTAL MASS OF THE AERO-WINDOWS (KG)
MAWF     = DELIVERED MASS OF THE AERO-WINDOW FLUID (KG)
MBASE    = TOTAL MASS OF THE LASER NOZZLE BASES (KG)
MCAV     = TOTAL MASS OF THE LASER CAVITIES (KG)
MCB      = TOTAL MASS OF THE COMBUSTOR BODIES (KG)
MCONE    = TOTAL MASS OF THE EJECTOR PRIMARY NOZZLE CONES (KG)
MCS      = MASS OF THE COOLING SYSTEM (KG)
MCSF     = MASS OF THE COOLING SYSTEM FLUID (KG)
MDS      = MASS OF THE DEVICE SUPPORT (KG)
MEJECT   = TOTAL MASS OF THE EJECTORS (KG)
MELINE   = MASS OF THE EJECTOR REACTANT FEED LINES (KG)
MEPNE    = MACH NO. AT THE EJECTOR PRIMARY NOZZLE EXIT
MEPR     = DELIVERED MASS OF THE EJECTOR PRIMARY REACTANT (KG)
MERREG   = MASS OF THE EJECTOR PRIMARY REACTANT REGULATOR (KG)
MERT     = MASS OF THE EJECTOR PRIMARY REACTANT TANKAGE AND FLUID (KG)
MHE      = DELIVERED MASS OF HE (KG)
MINJ     = TOTAL MASS OF THE INJECTORS (KG)
MLDHDW   = MASS OF THE LASER DEVICE HARDWARE (KG)
MLDS     = MASS OF THE LASER DEVICE SYSTEM (KG)
MLLINE   = MASS OF THE LASER REACTANT FEED LINES (KG)
MLPR     = DELIVERED MASS OF THE LASER PRIMARY REACTANT (KG)
MLRREG   = MASS OF THE LASER REACTANT REGULATOR (KG)
MLRT     = MASS OF THE LASER REACTANT TANKAGE AND FLUID (KG)
MLSR     = DELIVERED MASS OF THE LASER SECONDARY REACTANT (KG)
MMIR     = MASS OF A MIRROR (KG)
MMISC    = MASS OF MISCELLANEOUS ITEMS (KG)
MOPT     = TOTAL MASS OF THE LASER OPTICS (KG)
MPLEN    = TOTAL MASS OF THE EJECTOR PRIMARY NOZZLE PLENNUMS (KG)
MPRHDW   = MASS OF THE PRESSURE RECOVERY HARDWARE (KG)
MPRS     = MASS OF THE PRESSURE RECOVERY SYSTEM (KG)
MSHRD    = TOTAL MASS OF THE EJECTOR SHROUDS (KG)
MSTRUT   = TOTAL MASS OF THE EJECTOR PRIMARY NOZZLE STRUTS (KG)
MSUBD    = TOTAL MASS OF THE SUBSONIC DIFFUSERS (KG)
MSUPD    = TOTAL MASS OF THE SUPERSONIC DIFFUSERS (KG)
```

MTOTAL = TOTAL SYSTEM MASS [KG]
MTR = TOTAL MASS OF THE TRANSITION SECTIONS [KG]
NBANK = NUMBER OF LASER BANKS
NEJECT = NUMBER OF EJECTORS PER LASER BANK
= 0, FOR THE MAXIMUM ALLOWABLE
NMAX = INTERMEDIATE CONSTANT
NO = ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NTANK = NUMBER OF TANKS
N1 = NUMBER OF CARBON ATOMS IN LASER PRIMARY REACTANT 1
N2 = NUMBER OF HYDROGEN (DEUTERIUM) ATOMS IN LASER PRIMARY REACTANT 2
N3 = NUMBER OF NITROGEN ATOMS IN LASER PRIMARY REACTANT 4
N4 = NUMBER OF FLUORINE ATOMS IN LASER PRIMARY REACTANT 4
P0 = STAGNATION PRESSURE [PA]
P0EP = EJECTOR PRIMARY STAGNATION PRESSURE [PA]
P0LP = LASER PRIMARY STAGNATION PRESSURE [PA]
P0LS = LASER SECONDARY STAGNATION PRESSURE [PA]
Q = HEAT RELEASED PER KMOLE OF PRIMARY FLOW BY THE CHEMICAL REACTION OF FLUORINE IN THE LASER CAVITY [J/KMOLE]
RTIME = RUN TIME [S]
SCSS1 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW SYSTEM CALCULATION INPUTS ARE REQUIRED
SCSS2 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT SYSTEM CALCULATIONS ARE TO BE PERFORMED
SCSS3 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT INPUT DATA SHOULD BE READ FROM TAPE4
SCSS4 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW REACTANT STORAGE MODES ARE REQUIRED
SDANGL = SUBSONIC DIFFUSER HALF-ANGLE [RAD]
SETSCS = CONTROL VARIABLE TO SET DEFAULT VALUES
SSE = ALPHANUMERIC SYMBOL DESIGNATING A SUPERSONIC-SUPERSONIC EJECTOR FOR PRESSURE RECOVERY
STAW = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2-AW
STCS = STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2O-CS
STC2H4 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR C2H4
STD2 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR D2
STF2 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR F2
STHE = STORAGE MODE DESCRIPTOR DATA ARRAY FOR HE
STH2 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2
STIRFNA = STORAGE MODE DESCRIPTOR DATA ARRAY FOR IRFNA
STMMH = STORAGE MODE DESCRIPTOR DATA ARRAY FOR MMH
STMODE = REACTANT STORAGE MODE DESCRIPTOR ARRAY
STNF3 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR NF3
STN2 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2
STN2H4 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2H4
TAU = MATERIAL THICKNESS [M]
THETA = INITIAL TRANSITION SECTION HALF-ANGLE IN THE HORIZONTAL PLANE [RAD]
TITLE = ARRAY OF STORAGE MODE HEADINGS FOR I/O
TRANG1 = INITIAL TRANSITION SECTION HALF-ANGLE IN THE VERTICLE PLANE [RAD]
TRANG2 = FINAL TRANSITION SECTION HALF-ANGLE [RAD]
VAW = TOTAL VOLUME OF THE AERO-WINDOWS [M3]
VBXDEV = VOLUME OF THE BOX DEVICE [M3]
VCAV = TOTAL VOLUME OF THE LASER CAVITIES [M3]

VCOMB = TOTAL VOLUME OF THE LASER COMBUSTORS [M3]
VCS = VOLUME OF THE COOLING SYSTEM [M3]
VEJECT = TOTAL VOLUME OF THE EJECTORS [M3]
VERT = VOLUME OF THE EJECTOR PRIMARY REATANT TANKAGE [M3]
VLDHDW = VOLUME OF THE LASER DEVICE HARDWARE [M3]
VLDS = VOLUME OF THE LASER DEVICE SYSTEM [M3]
VLRT = VOLUME OF THE LASER REACTANT TANKAGE [M3]
VOPT = TOTAL VOLUME OF THE LASER OPTICS [M3]
VPRHDW = VOLUME OF THE PRESSURE RECOVERY HARDWARE [M3]
VPRS = VOLUME OF THE PRESSURE RECOVERY SYSTEM [M3]
VSUBD = TOTAL VOLUME OF THE SUBSONIC DIFFUSERS [M3]
VSUPD = TOTAL VOLUME OF THE SUPERSONIC DIFFUSERS [M3]
VSYSTM = TOTAL VOLUME CONTAINING THE SYSTEM [M3]
VTOTAL = TOTAL VOLUME OCCUPIED BY THE SYSTEM [M3]
VTR = TOTAL VOLUME OF THE TRANSITION SECTIONS [M3]
WAW = AERO-WINDOW MASS FLOW RATE [KG/S]
WAWL = AERO-WINDOW FLUID LEAKAGE RATE [KG/S]
WBASE = WIDTH OF A NOZZLE BASE [M3]
WBXDEV = WIDTH OF THE BOX DEVICE [M3]
WCB = WIDTH OF A COMBUSTOR BODY [M3]
WCS = COOLING SYSTEM MASS FLOW RATE [KG/S]
WEP = EJECTOR PRIMARY REACTANT MASS FLOW RATE [KG/S]
WEPWLT = EJECTOR PRIMARY-TO-TOTAL LASER MASS FLOW RATIO
WFPP3 = MASS FRACTION OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)
WFPR1 = MASS FRACTION OF LASER PRIMARY REACTANT 1
WFPR2 = MASS FRACTION OF LASER PRIMARY REACTANT 2
WFPR3 = MASS FRACTION OF LASER PRIMARY REACTANT 3
WFPR4 = MASS FRACTION OF LASER PRIMARY REACTANT 4
WFSR1 = MASS FRACTION OF LASER SECONDARY REACTANT 1
WFSR2 = MASS FRACTION OF LASER SECONDARY REACTANT 2
WFSR3 = MASS FRACTION OF LASER SECONDARY REACTANT 3
WLP = LASER PRIMARY REACTANT MASS FLOW RATE [KG/S]
WLS = LASER SECONDARY REACTANT MASS FLOW RATE [KG/S]
WLSWLP = LASER SECONDARY-TO-PRIMARY REACTANT MASS FLOW RATIO
WLT = TOTAL LASER MASS FLOW RATE [KG/S]
WNB = WIDTH OF A NOZZLE BANK [M]
WPGWLP = LASER CAVITY PURGE-TO-PRIMARY REACTANT MASS FLOW RATIO
WPP3 = MASS FLOW RATE OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE) [KG/S]
WPURGE = CAVITY PURGE MASS FLOW RATE [KG/S]
WTR = WIDTH OF A TRANSITION SECTION ENTRANCE [M]
XFPP3 = MOLE FRACTION OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)
XLP = LASER PRIMARY PRODUCT MOLAR FLOW RATE [KMOLE/S]
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

REACTANT STORAGE MODE NOTATION SCHEME

THE STORAGE MODE DESCRIPTOR ARRAY, STMODE(I,J), STORES DATA BY DESCRIPTOR (ROW) AS FOLLOWS:

I DESCRIPTOR
1 REACTANT
2 PHASE
3 CONTAINER
4 STORAGE TEMPERATURE (K)
5 STORAGE TIME (S)
I DESCRIPTOR
6 STORAGE TIME (DAYS)
7 STORAGE PRESSURE (PA)
8 STORAGE PRESSURE (PSI)
9 REACTANT FEED SYSTEM
10 MATERIAL

AND BY FLUID (COLUMN) AS FOLLOWS:

J
1 DESCRIPTOR
2 LASER REACTANT 1
3 LASER REACTANT 2
4 LASER REACTANT 3
5 LASER REACTANT 4
J
6 LASER REACTANT 5
7 AERO-WINDOW FLUID
8 COOLING SYSTEM FLUID
9 EJECTOR REACTANT 1
10 EJECTOR REACTANT 2

SOME POSSIBLE ALPHANUMERIC DESCRIPTOR VALUES ARE:

REACTANT -	C2H4, D2, F2, HF, H2, IRFNA MMH, NF3, N2, N2H4 F2/HE - F2 AND HE GAS MIXTURE NF3/HE - NF3 AND HE GAS MIXTURE N2-AW - N2 FOR THE AERO-WINDOW H2O-CS - H2O FOR THE COOLING SYSTEM
PHASE -	GAS LIQ, LIQUID
CONTAINER -	SPH, SPHERE CYL, CYLINDER
REACTANT FEED SYSTEM -	BLD, BLOW-DOWN HPS, HEATER PRESSURIZATION SYSTEM PFS, PUKP FEED SYSTEM PGS, PRESSURIZED GAS SYSTEM RFP, RADIATOR-FAN-PUMP
MATERIAL -	AL, ALUMINUM SS, STAINLESS STEEL TI, TITANIUM

NOMENCLATURE FOR SUBROUTINES VMAW, VMCS, VMC2H4, VMD2,
VMF2, VMHE, VMH2, VMIRFNA, VMMMH, VMNF3, VMN2, VMN2H4

AF = ADIABATIC FACTOR
G = SPECIFIC HEAT RATIO
I = DO LOOP INDEX
II = DO LOOP INDEX
J = STORAGE MODE CONTROL VARIABLE
K = STORAGE MODE CONTROL ARRAY
MCS = MASS OF THE COOLING SYSTEM (KG)
MC2H4 = DELIVERED MASS OF C2H4 (KG)
MD2 = DELIVERED MASS OF D2 (KG)
MF2 = DELIVERED MASS OF F2 (KG)
MHE = DELIVERED MASS OF HE (KG)
MH2 = DELIVERED MASS OF H2 (KG)
MH2O = DELIVERED MASS OF H2O (KG)
MIRFNA = DELIVERED MASS OF IRFNA (KG)
MMMH = DELIVERED MASS OF MMH (KG)
MMT = TANK AND FLUID MASS USING MINIMUM THICKNESS EQUATIONS (KG)
MNF3 = DELIVERED MASS OF NF3 (KG)
MN2 = DELIVERED MASS OF N2 (KG)
MN2H4 = DELIVERED MASS OF N2H4 (KG)
MPGS = DELIVERED MASS OF FLUID FROM A PRESSURIZED GAS SYSTEM (KG)
MTANK = MASS OF REACTANT TANKAGE AND FLUID (KG)
MTOTAL = DELIVERED MASS OF GAS MIXTURE (KG)
MTTHPS = MASS OF TANK AND FLUID FOR A HEATER PRESSURIZATION SYSTEM (KG)
MTTPGS = MASS OF TANK AND FLUID FOR A PRESSURIZED GAS SYSTEM (KG)
MVT = TANK AND FLUID MASS USING VARIABLE THICKNESS EQUATIONS (KG)
MW = MOLECULAR WEIGHT (KG/KMOLE)
PHE = PARTIAL PRESSURE OF HE (PA)
PS = REACTANT STORAGE PRESSURE (PA)
P0 = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
RTIME = RUN TIME (S)
STAW = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2-AW
STCS = STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2O-CS
STC2H4 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR C2H4
STD2 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR D2
STF2 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR F2
STHE = STORAGE MODE DESCRIPTOR DATA ARRAY FOR HE
STH2 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2
STIRFNA = STORAGE MODE DESCRIPTOR DATA ARRAY FOR IRFNA
STMMH = STORAGE MODE DESCRIPTOR DATA ARRAY FOR MMH
STMODE = REACTANT STORAGE MODE DESCRIPTOR ARRAY
STNF3 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR NF3
STN2 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2
STN2H4 = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2H4
VCS = VOLUME OF THE COOLING SYSTEM (M3)
VTANK = VOLUME OF THE REACTANT TANKAGE (M3)
VTTHPS = VOLUME OF A HEATER PRESSURIZATION SYSTEM (M3)
VTTPGS = VOLUME OF A PRESSURIZED GAS SYSTEM (M3)
XFF2 = MOLE FRACTION OF F2
XFHE = MOLE FRACTION OF HE
XFNF3 = MOLE FRACTION OF NF3
Z = COMPRESSIBILITY FACTOR

```
ZHE      = COMPRESSIBILITY FACTOR FOR HF
```

FUNCTION STATEMENT GENERAL NOTATION SCHEME

AASM = ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR A/A* AS A FUNCTION OF MACH NUMBER

PPOM = ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR P/PO AS A FUNCTION OF MACH NUMBER

POPM = ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR PO/P AS A FUNCTION OF MACH NUMBER

RHO = DENSITY FROM THE IDEAL GAS EQUATION OF STATE

RORM = ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR RO/R AS A FUNCTION OF MACH NUMBER

TOTM = ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR TO/T AS A FUNCTION OF MACH NUMBER

WM = ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR THE DIMENSIONLESS MASS FLOW RATE AS A FUNCTION OF MACH NUMBER

Appendix G. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)-SAMPLE INPUT/OUTPUT

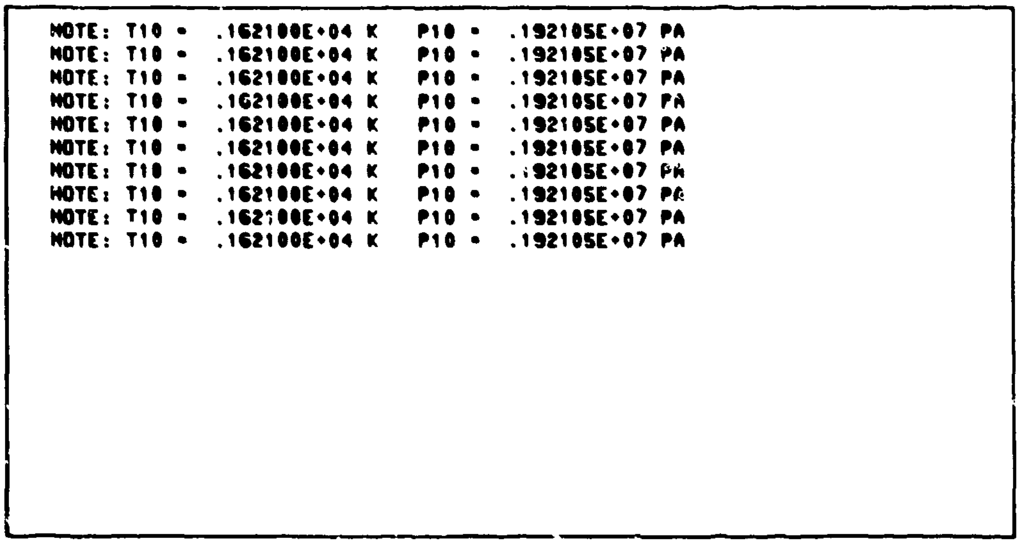
SAMPLE CASE 1 (DEFAULT CASE): INPUT

```
ARE NEW COMBUSTION CHEMISTRY INPUTS REQUIRED?

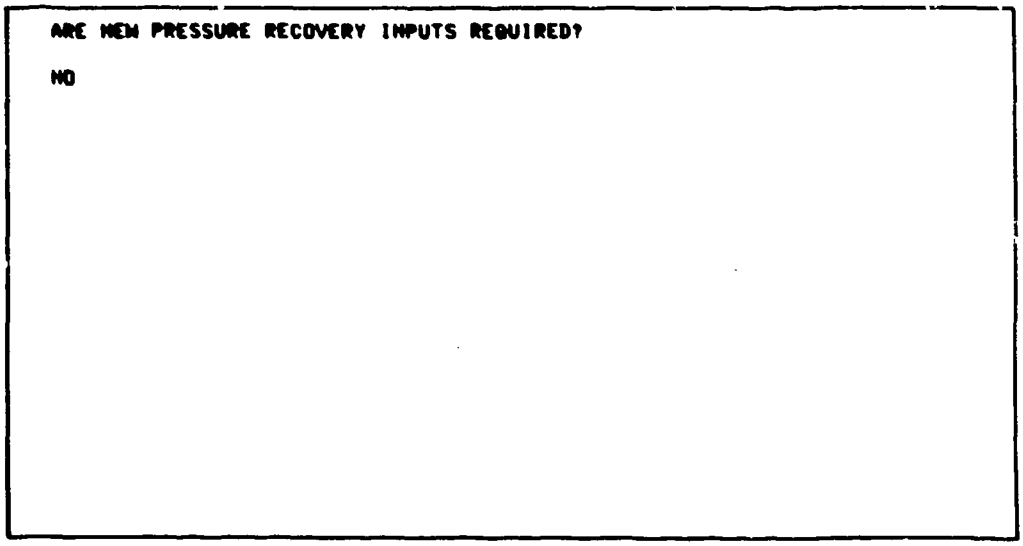
NO
```

```
ARE NEW LASER DEVICE INPUTS REQUIRED?

NO
```

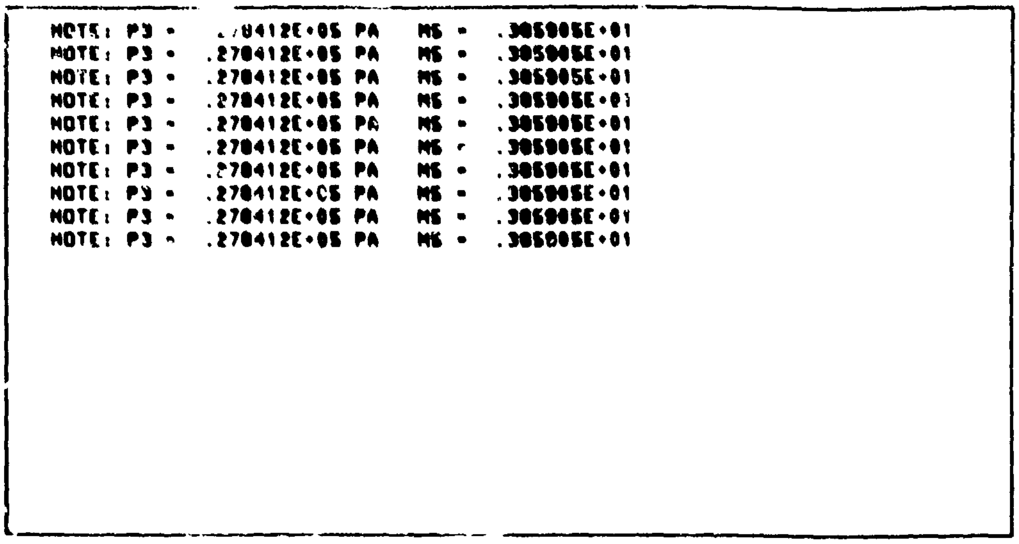


```
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
NOTE: T10 =  .162100E+04 K   P10 =  .192105E+07 PA
```

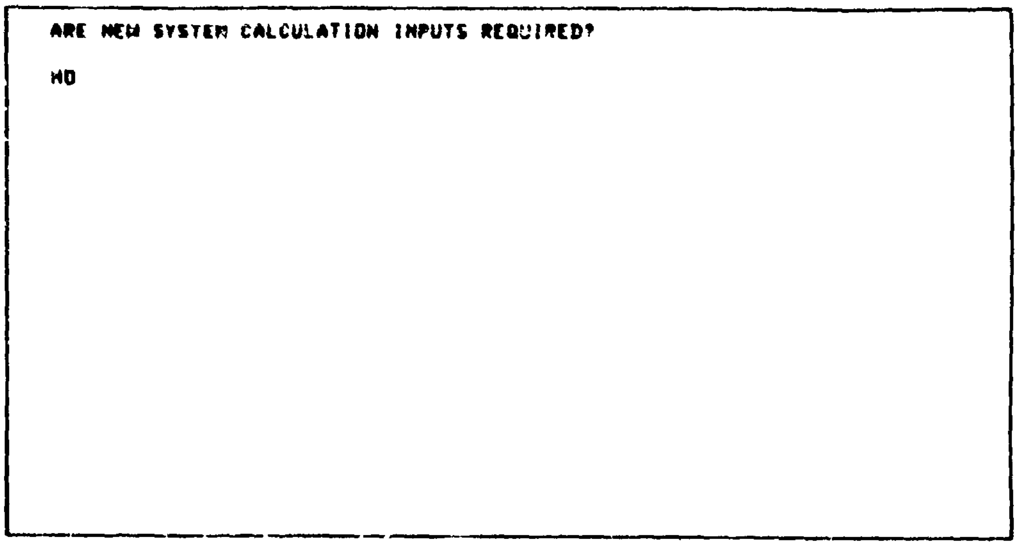


```
ARE NEW PRESSURE RECOVERY INPUTS REQUIRED?

NO
```



```
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
NOTE: P3 =  .270412E+05 PA   MS =  .305905E+01
```



```
ARE NEW SYSTEM CALCULATION INPUTS REQUIRED?

NO
```

```
TO RESTART PROGRAM ENTER "YES"

TO STOP PROGRAM ENTER "NO"

NO
```

APPENDIX G   CLAP SAMPLE INPUT/OUTPUT

SAMPLE CASE 1 (DEFAULT CASE): OUTPUT (SI UNITS)

```
                         CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

                              WRITTEN BY: C.L. ADAMS
                                          A.L. ADDY
                                          R.D. MASSEY
                                          C.D. MIKKELSEN
                                          G.F. MORR
                                          R.L. OGLUKIAN
                                          B.J. WALKER

                                    1 JANUARY 77

                            AERODYNAMICS GROUP (DRDMI-TDK)
                            SYSTEM SIMULATION DIRECTORATE
                  U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
                            REDSTONE ARSENAL, ALABAMA 35809

                                 RUN DATE  12/05/78


                            COMBUSTION CHEMISTRY SECTION

                                   INITIAL DATA:

         AEXP     =  .361935E-02 M2          ALPHA    =  .802700E+00
         DFORNF   =   DF                     N1       =            2 ATOMS C
         N2       =            4 ATOMS H     N3       =            1 ATOMS N
         N4       =            3 ATOMS F     WPB      = 0.           KG/S N2
         WPR1     =  .362160E-02 KG/S C2H4   WPR2     =  .172416E-01 KG/S HE
         WPR3     = 0.           KG/S N2     WPR4     =  .571093E-01 KG/S N1F3
         WSR1     =  .437250E-02 KG/S D2     WSR2     =  .338518E-01 KG/S HE
         WSR3     = 0.           KG/S N2

                                  RESULTANT DATA:

         FDAA     =  .191592E+00 KMOLE/S-M2 OMEGA    =  .347901E+02
         OMEGTRW  =  .322770E+02             PSIC     =  .126969E+02
         PSIL     =  .229931E+02             PSILTRW  =  .195801E+02
         Q        =  .218542E+08 J/KMOLE     RC       =  .207688E+01
         RL       =  .251301E+01             RLF      =  .220931E+02

         WFCP1    =  .195543E+00 CF4         XFCP1    =  .160238E-01 CF4
         WFCP2    =  .889077E-01 HF          XFCP2    =  .320476E-01 HF
         WFCP3    =  .156220E+00 DF          XFCP3    =  .536149E-01 DF
         WFCP4    =  .439714E+00 HE          XFCP4    =  .792234E+00 HE
         WFCP5    =  .969568E-01 N2          XFCP5    =  .249596E-01 N2
         WFCP6    =  .226560E-01 D           XFCP6    =  .811199E-01 D
```

```
                               LASER DEVICE SECTION

                                  INITIAL DATA:

          BRFRAC   =  .100000E+01              CANGLE   =  .174533E+00 RAD
          D1       =  .177800E-02 M            D1S      =  .669534E-04 M
          D3       =  .137160E-02 M            D3S      =  .685800E-04 M
          GEOMPN   =   2D                      GEOMSN   =   2D
          HBASE    =  .349250E-01 M            HNB      =  .349250E-01 M
          LCAV     =  .762000E-01 M            LPNOZ    =  .250190E-02 M
          LSNOZ    =  .185166E-02 M            NSPNOZ   =  .103846E+01
          PKFRAC   =  .803431E+00              P10      =  .192105E+07 PA
          T30      =  .600000E+03 K            T70      =  .300000E+03 K

                                 RESULTANT DATA:

POINT 1   PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION
          (COMBUSTOR) TEMPERATURE

          A1       =  .173248E+00 S-M2/KMOLE A1A1SE   =  .178471E+02
          A1A1SG   =  .265958E+02              G1       =  .145968E+01
          MW1      =  .124497E+02 KG/KMOLE     M1       =  .491266E+01
          NPNOZ    =  .415138E+04 S/KMOLE      P1       =  .492323E+04 PA
          P10      =  .192105E+07 PA           RE1      =  .222422E+04
          R1       =  .297744E-01 KG/M3        R10      =  .177455E+01 KG/M3
          T1       =  .247594E+03 K            T10      =  .162100E+04 K

POINT 2   PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT
          TEMPERATURE

          A2       =  .157485E+00 S-M2/KMOLE G2       =  .153963E+01
          MW2      =  .124497E+02 KG/KMOLE     M2       =  .491266E+01
          P2       =  .492323E+04 PA           P20      =  .192105E+07 PA
          R2       =  .297744E-01 KG/M3        R20      =  .177455E+01 KG/M3
          T2       =  .247594E+03 K            T20      =  .162100E+04 K

POINT 3   SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION
          (COMBUSTOR) TEMPERATURE

          A3       =  .135591E+00 S-M2/KMOLE A3A3SE   =  .131315E+02
          A3A3SG   =  .200000E+02              G3       =  .161679E+01
          MW3      =  .400551E+01 KG/KMOLE     M3       =  .530231E+01
          NSNOZ    =  .431104E+04 S/KMOLE      P3       =  .239593E+04 PA
          P30      =  .917516E+06 PA           RE3      =  .187829E+04
          R3       =  .186036E-01 KG/M3        R30      =  .736704E+00 KG/M3
          T3       =  .620454E+02 K            T30      =  .600000E+03 K
          W3W1     =  .490228E+00              X3X1     =  .152370E+01

POINT 4   SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT
          TEMPERATURE

          A4       =  .136095E+00 S-M2/KMOLE G4       =  .161322E+01
          MW4      =  .400551E+01 KG/KMOLE     M4       =  .530231E+01
          P4       =  .239593E+04 PA           P40      =  .917516E+06 PA
          R4       =  .186036E-01 KG/M3        R40      =  .736704E+00 KG/M3
          T4       =  .620454E+02 K            T40      =  .600000E+03 K
          W4W2     =  .490228E+00              X4X2     =  .152370E+01
```

```
POINT 5  CONSTANT-AREA MIXING REGION EXIT

         A5       =  .293579E+00 S-M2/KMOLE G5       =  .158178E+01
         MW5      =  .735148E+01 KG/KMOLE   M5       =  .489482E+01
         P5       =  .391429E+04 PA         P50      =  .110540E+07 PA
         R5       =  .269217E-01 KG/M3      R50      =  .953972E+00 KG/M3
         T5       =  .128558E+03 K          T50      =  .102454E+04 K
         W5W2     =  .149023E+01            X5X2     =  .252370E+01

POINT 6  ISENTROPIC EXPANSION REGION EXIT

         A6       =  .577895E+00 S-M2/KMOLE G6       =  .158178E+01
         MW6      =  .735148E+01 KG/KMOLE   M6       =  .614393E+01
         P6       =  .129211E+04 PA         P60      =  .110540E+07 PA
         R6       =  .133595E-01 KG/M3      R60      =  .953972E+00 KG/M3
         T6       =  .855175E+02 K          T60      =  .102454E+04 K
         W6W2     =  .149023E+01            X6X2     =  .252370E+01

POINT 7  MIRROR PURGE CONDITIONS

         G7       =  .139962E+01            MW7      =  .280134E+02 KG/KMOLE
         T70      =  .300000E+03 K          W7W2     = 0.
         X7X2     = 0.

POINT 8  LASER CAVITY EXIT

         A8       =  .102254E+01 S-M2/KMOLE G8       =  .157796E+01
         MW8      =  .721149E+01 KG/KMOLE   M8       =  .226203E+01
         P8       =  .511063E+04 PA         P80      =  .609213E+05 PA
         RE8      =  .379253E+05            R8       =  .795592E-02 KG/M3
         R80      =  .382623E-01 KG/M3      T8       =  .557161E+03 K
         T80      =  .138100E+04 K          W8W2     =  .149023E+01
         X8X2     =  .257269E+01
```

```
                              PRESSURE RECOVERY SECTION

                                   INITIAL DATA:

           A3A2     =  .300000E+01                A7A6     =  .300000E+01
           EJECT    =   CAE                       ETA12    =  .750000E+00
           G5       =  .129000E+01                MW5      =  .202040E+02 KG/KMOLE
           P50      =  .310264E+07 PA             P7       =  .101325E+06 PA
           T50      =  .281480E+04 K

                                  RESULTANT DATA:

POINT 1  LASER CAVITY EXIT AND NORMAL SHOCK DIFFUSER ENTRANCE

           A1       =  .102254E+01 S-M2/KMOLE G1       =  .157796E+01
           MW1      =  .721149E+01 KG/KMOLE   M1       =  .226203E+01
           P1       =  .511063E+04 PA         P10      =  .609213E+05 PA
           R1       =  .795592E-02 KG/M3      R10      =  .382623E-01 KG/M3
           T1       =  .557161E+03 K          T10      =  .138100E+04 K

POINT 2  NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DIFFUSER ENTRANCE

           A2       =  .102254E+01 S-M2/KMOLE ETA12    =  .750000E+00
           G2       =  .157796E+01            MW2      =  .721149E+01 KG/KMOLE
           M2       =  .554255E+00            P2       =  .231501E+05 PA
           P20      =  .294386E+05 PA         R2       =  .158775E-01 KG/M3
           R20      =  .184892E-01 KG/M3      T2       =  .126465E+04 K
           T20      =  .138100E+04 K          W2W1     =  .100000E+01
           X2X1     =  .100000E+01

POINT 3  SUBSONIC DIFFUSER EXIT AND SUDDEN ENLARGEMENT ENTRANCE

           A3       =  .306763E+01 S-M2/KMOLE ETA23    =  .964251E+00
           G3       =  .157796E+01            MW3      =  .721149E+01 KG/KMOLE
           M3       =  .157029E+00            P3       =  .278412E+05 PA
           P30      =  .283862E+05 PA         R3       =  .176106E-01 KG/M3
           R30      =  .178283E-01 KG/M3      T3       =  .137123E+04 K
           T30      =  .138100E+04 K          W3W1     =  .100000E+01
           X3X1     =  .100000E+01

POINT 4  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SECONDARY NOZZLE EXIT

           A4       =  .120834E+01 S-M2/KMOLE G4       =  .157796E+01
           MW4      =  .721149E+01 KG/KMOLE   M4       =  .775000E+00
           P4       =  .183449E+05 PA         P40      =  .283862E+05 PA
           R4       =  .135215E-01 KG/M3      R40      =  .178283E-01 KG/M3
           T4       =  .117676E+04 K          T40      =  .138100E+04 K
           W4W1     =  .100000E+01            X4X1     =  .100000E+01

POINT 5  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR PRIMARY NOZZLE EXIT

           A5       =  .391545E+00 S-M2/KMOLE G5       =  .129000E+01
           MW5      =  .202040E+02 KG/KMOLE   M5       =  .385905E+01
           P5       =  .185938E+05 PA         P50      =  .310264E+07 PA
           R5       =  .507143E-01 KG/M3      R50      =  .267851E+01 KG/M3
           T5       =  .890936E+03 K          T50      =  .281480E+04 K
           W5W1     =  .284443E+01            X5X1     =  .101527E+01
```

```
POINT 6  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR EXIT AND SUBSONIC
         DIFFUSER ENTRANCE

         A6      =  .159989E+01 S-M2/KMOLE G6      =  .138524E+01
         MW6     =  .137570E+02 KG/KMOLE   M6      =  .482248E+00
         P6      =  .899720E+05 PA         P60     =  .105327E+06 PA
         R6      =  .683803E-01 KG/M3      R60     =  .766185E-01 KG/M3
         T6      =  .217707E+04 K          T60     =  .227459E+04 K
         W6W1    =  .384443E+01            X6X1    =  .201527E+01

POINT 7  SUBSONIC DIFFUSER EXIT

         A7      =  .479966E+01 S-M2/KMOLE ETA67   =  .975871E+00
         G7      =  .138524E+01            MW7     =  .137570E+02 KG/KMOLE
         M7      =  .142052E+00            P7      =  .101325E+06 PA
         P70     =  .102786E+06 PA         R7      =  .739935E-01 KG/M3
         R70     =  .747698E-01 KG/M3      T7      =  .226579E+04 K
         T70     =  .227459E+04 K          W7W1    =  .384443E+01
         X7X1    =  .201527E+01
```

```
                         SYSTEM CALCULATION SECTION

                                INITIAL DATA:

EREACT   =    IRFNA/MMH                  NBANK    =            1
NEJECT   =              1                RTIME    =   .600000E+02 S
WPP3     =   .109645E+03 KG/S

                          REACTANT STORAGE METHOD

 REACT         C2H4      HE                        NF3          D2
 PHASE         GAS       GAS                       GAS          GAS
 CONT          SPH       SPH                       SPH          SPH
 STEMP         300.0 K   300.0 K                   300.0 K      300.0 K
 STIME         INFINITE  INFINITE                  INFINITE     INFINITE

 SPRES         4.1E+07 PA 4.1E+07 PA               1.2E+07 PA 4.1E+07 PA
               (6000 PSI) (6000 PSI)               (1800 PSI) (6000 PSI)
 RFSYS         BLD        BLD                      BLD        BLD
 MATER         TI         TI                       SS         TI

 REACT         N2-AW      H2O-CS     MMH           IRFNA
 PHASE         GAS        LIQ        LIQ           LIQ
 CONT          SPH        SPH        SPH           SPH
 STEMP         300.0 K    300.0 K    300.0 K       300.0 K
 STIME         INFINITE   INFINITE   INFINITE      INFINITE

 SPRES         4.1E+07 PA 2.8E+06 PA 1.25*P0       1.25*P0
               (6000 PSI) (400 PSI)
 RFSYS         BLD        PGS        PGS           PGS
 MATER         TI         TI         TI            AL

                                RESULTANT DATA:

                          SYSTEM SCALE-UP FACTOR

XLP      =   .901567E+00 KMOLE/S

                      LASER DEVICE SYSTEM VOLUME/MASS

MINJ     =   .502582E+02 KG
MCB      =   .835375E+02 KG
MBASE    =   .785727E+02 KG             VCOMB    =   .592590E-01 M3
MCAV     =   .232102E+02 KG             VCAV     =   .549746E-01 M3
MAW      =   .144447E+02 KG             VAW      =   .108258E-01 M3
MCS      =   .626465E+03 KG             VCS      =   .634179E+00 M3
MOPT     =   .114917E+04 KG             VOPT     =   .107473E+01 M3
MDS      =   .138475E+03 KG
MLPREG   =   .669069E+02 KG
MLLINE   =   .259070E+02 KG
             -----------                             -----------
MLDHDW   =   .225695E+04 KG             VLDHDW   =   .183397E+01 M3
MLRT     =   .908326E+04 KG             VLRT     =   .132811E+02 M3
             -----------                             -----------
MLDS     =   .113402E+05 KG             VLDS     =   .151151E+02 M3
```

```
                         PRESSURE RECOVERY SYSTEM VOLUME/MASS

          MSUPD   =  .250459E+03 KG          VSUPD   =  .512733E+00 M3
          MSUBD   =  .941716E+02 KG          VSUBD   =  .233867E+00 M3
          MEJECT  =  .156135E+05 KG          VEJECT  =  .101376E+03 M3
          MERREG  =  .118949E+03 KG
          MELINE  =  .675493E+01 KG
                     ___________                         ___________
          MPRHOW  =  .160839E+05 KG          VPRHOW  =  .102123E+03 M3
          MERT    =  .407555E+04 KG          VERT    =  .390099E+01 M3
                     ___________                         ___________
          MPRS    =  .201594E+05 KG          VPRS    =  .106024E+03 M3

                            SYSTEM VOLUME/MASS SUMMARY

          MLDS    =  .113402E+05 KG          VLDS    =  .151151E+02 M3
          MPRS    =  .201594E+05 KG          VPRS    =  .106024E+03 M3
          MMISC   =  .362874E+03 KG
                     ___________                         ___________
          MTOTAL  =  .318625E+05 KG          VTOTAL  =  .121139E+03 M3
                                             VSYSTM  =  .242277E+03 M3

          WBASE   =  .149180E+02 M           LLDS    =  .189938E+00 M
          LPRS    =  .337920E+02 M

          LBXDEV  =  .339221E+02 M           WBXDEV  =  .164098E+02 M
          HBXDEV  =  .430213E+01 M           VBXDEV  =  .239479E+04 M3
```

SAMPLE CASE 1 (DEFAULT CASE): OUTPUT (ENGINEERING UNITS)

```
                    CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

                         WRITTEN BY: C.L. ADAMS
                                     A.L. ADDY
                                     R.D. MASSEY
                                     C.D. MIKKELSEN
                                     G.F. MOHR
                                     R.L. OGLUKIAN
                                     R.J. WALKER

                                1 JANUARY 77

                     AERODYNAMICS GROUP (DRDMI-TDK)
                     SYSTEM SIMULATION DIRECTORATE
              U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
                     REDSTONE ARSENAL, ALABAMA 35809

                           RUN DATE  12/05/78



                       COMBUSTION CHEMISTRY SECTION

                             INITIAL DATA:

AEXP      =  .561000E+01 IN2
DFORHF    =   DF                  ALPHA     =   .802700E+00
N2        =             4 ATOMS H N1        =              2 ATOMS C
N4        =             3 ATOMS F N3        =              1 ATOMS N
WPR1      =  .362[illegible]E+01 GM/S C2H4  WFG       =  0.            GM/S N2
WPR3      =  0.          GM/S N2  WPR2      =   .172416E+02 GM/S HE
WSR1      =  .437250E+01 GM/S O2  WPR4      =   .571093E+02 GM/S NIF3
WSR3      =  0.          GM/S N2  WSR2      =   .330518E+02 GM/S HE

                            RESULTANT DATA:

FDAA      =  .123607E+00 GMOLE/S-IN2 OMEGA     =  .347901E+02
OMEGTRW   =  .322770E+02             PSIC      =  .126969E+02
PSIL      =  .220931E+02             PSILTRW   =  .195801E+02
@         =  .522329E+04 CAL/GMOLE   RC        =  .207680E+01
RL        =  .251301E+01             RLF       =  .220931E+02

WFCP1     =  .195545E+00 CF4         XFCP1     =  .160238E-01 CF4
WFCP2     =  .889077E-01 HF          XFCP2     =  .320476E-01 HF
WFCP3     =  .156220E+00 DF          XFCP3     =  .536149E-01 DF
WFCP4     =  .439714E+00 HE          XFCP4     =  .792234E+00 HE
WFCP5     =  .969568E-01 N2          XFCP5     =  .249596E-01 N2
WFCP6     =  .[illegible]5560E-01 D           XFCP6     =  .811199E-01 D
```

```
                                LASER DEVICE SECTION

                                   INITIAL DATA:

         BRFRAC   =  .100000E+01                 CANGLE   =  .100000E+02 DEG
         D1       =  .700000E-01 IN              D1S      =  .263596E-02 IN
         D3       =  .540000E-01 IN              D3S      =  .270000E-02 IN
         GEOMPN   =   2D                         GEOMSN   =   2D
         HBASE    =  .137500E+01 IN              HNB      =  .137500E+01 IN
         LCAV     =  .300000E+01 IN              LPNOZ    =  .985000E-01 IN
         LSNOZ    =  .729000E-01 IN              NSPNOZ   =  .103846E+01
         PRFRAC   =  .803431E+00                 P10      =  .278625E+03 PSIA
         T30      =  .600000E+03 K               T70      =  .300000E+03 K

                                  RESULTANT DATA:

POINT 1  PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION
         (COMBUSTOR) TEMPERATURE

         A1       =  .121805E+03 S-IN2/LBMOLE A1A1SE   =  .178471E+02
         A1A1SG   =  .265558E+02                 G1       =  .145968E+01
         MW1      =  .124497E+02 LBM/LBMOLE      M1       =  .491266E+01
         NPNOZ    =  .188302E+04 S/LBMOLE        P1       =  .369273E+02 TORR
         P10      =  .278625E+03 PSIA            RE1      =  .222422E+04
         R1       =  .297744E-04 GM/CM3          R10      =  .177455E-02 GM/CM3
         T1       =  .247594E+03 K               T10      =  .162100E+04 K

POINT 2  PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT
         TEMPERATURE

         A2       =  .110722E+03 S-IN2/LBMOLE G2       =  .153963E+01
         MW2      =  .124497E+02 LBM/LBMOLE      M2       =  .491266E+01
         P2       =  .369273E+02 TORR            P20      =  .278625E+03 PSIA
         R2       =  .297744E-04 GM/CM3          R2       =  .177455E-02 GM/CM3
         T2       =  .247594E+03 K               T20      =  .162100E+04 K

POINT 3  SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION
         (COMBUSTOR) TEMPERATURE

         A3       =  .953294E+02 S-IN2/LBMOLE A3A3SE   =  .131315E+02
         A3A3SG   =  .200000E+02                 G3       =  .161679E+01
         MW3      =  .400551E+01 LBM/LBMOLE      M3       =  .530231E+01
         NSNOZ3   =  .195544E+04 S/LBMOLE        P3       =  .179710E+02 TORR
         P30      =  .133074E+03 PSIA            RE3      =  .187829E+04
         R3       =  .186036E-04 GM/CM3          R30      =  .736704E-03 GM/CM3
         T3       =  .620454E+02 K               T30      =  .600000E+03 K
         W3W1     =  .490228E+00                 X3X1     =  .152370E+01

POINT 4  SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT
         TEMPERATURE

         A4       =  .956835E+02 S-IN2/LBMOLE G4       =  .161322E+01
         MW4      =  .400551E+01 LBM/LBMOLE      M4       =  .530231E+01
         P4       =  .179710E+02 TORR            P40      =  .133074E+03 PSIA
         R4       =  .186036E-04 GM/CM3          R40      =  .736704E-03 GM/CM3
         T4       =  .620434E+02 K               T40      =  .600000E+03 K
         W4W2     =  .490228E+00                 X4X2     =  .152370E+01
```

```
POINT 5  CONSTANT-AREA MIXING REGION EXIT

         A5       =  .206406E+03 S-IN2/LBMOLE G5       =  .158178E+01
         MW5      =  .735148E+01 LBM/LBMOLE   M5       =  .489482E+01
         P5       =  .293596E+02 TORR         P50      =  .829117E+04 TORR
         R5       =  .269217E-04 GM/CM3       R50      =  .953972E-03 GM/CM3
         T5       =  .128558E+03 K            T50      =  .102454E+04 K
         W5W2     =  .149023E+01              X5X2     =  .252370E+01

POINT 6  ISENTROPIC EXPANSION REGION EXIT

         A6       =  .406298E+03 S-IN2/LBMOLE G6       =  .158178E+01
         MW6      =  .735148E+01 LBM/LBMOLE   M6       =  .614393E+01
         P6       =  .969160E+01 TORR         P60      =  .829117E+04 TORR
         R6       =  .133595E-04 GM/CM3       R60      =  .953972E-03 GM/CM3
         T6       =  .855175E+02 K            T60      =  .102454E+04 K
         W6W2     =  .149023E+01              X6X2     =  .252370E+01

POINT 7  MIRROR PURGE CONDITIONS

         G7       =  .139962E+01              MW7      =  .280134E+02 LBM/LBMOLE
         T70      =  .300000E+03 K            W7W2     = 0.
         X7X2     = 0.

POINT 8  LASER CAVITY EXIT

         A8       =  .718915E+03 S-IN2/LBMOLE G8       =  .157796E+01
         MW8      =  .721149E+01 LBM/LBMOLE   M8       =  .226203E+01
         P8       =  .383328E+02 TORR         P80      =  .456947E+03 TORR
         RE8      =  .379253E+05              R8       =  .795592E-05 GM/CM3
         RA8      =  .382623E-04 GM/CM3       T8       =  .557161E+03 K
         T80      =  .138100E+04 K            W8W2     =  .149023E+01
         X8X2     =  .257269E+01
```

```
APPENDIX G                         CLAP SAMPLE INPUT/OUTPUT

                                   PRESSURE RECOVERY SECTION

                                         INITIAL DATA:

          A3A2     =  .300000E+01                   A7A6     =  .300000E+01
          EJECT    =   CAE                          ETA12    =  .750000E+00
          G5       =  .129000E+01                   MW5      =  .202040E+02 LBM/LBMOLE
          P50      =  .450000E+03 PSIA              PT       =  .760000E+03 TORR
          T50      =  .281480E+04 K

                                        RESULTANT DATA:

POINT 1  LASER CAVITY EXIT AND NORMAL SHOCK DIFFUSER ENTRANCE

          A1       =  .718915E+03 S-IN2/LBMOLE G1       =  .157796E+01
          MW1      =  .721149E+01 LBM/LBMOLE   M1       =  .226203E+01
          P1       =  .383328E+02 TORR         P10      =  .456947E+03 TORR
          R1       =  .795592E-05 GM/CM3       R10      =  .382623E-04 GM/CM3
          T1       =  .557161E+03 K            T10      =  .138100E+04 K

POINT 2  NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DIFFUSER ENTRANCE

          A2       =  .718915E+03 S-IN2/LBMOLE ETA12    =  .750000E+00
          G2       =  .157796E+01              MW2      =  .721149E+01 LBM/LBMOLE
          M2       =  .564255E+00              P2       =  .173640E+03 TORR
          P20      =  .220807E+03 TORR         R2       =  .158775E-04 GM/CM3
          R20      =  .184892E-04 GM/CM3       T2       =  .126465E+04 K
          T20      =  .138100E+04 K            W2W1     =  .100000E+01
          X2X1     =  .100000E+01

POINT 3  SUBSONIC DIFFUSER EXIT  AND SUDDEN ENLARGEMENT ENTRANCE

          A3       =  .215675E+04 S-IN2/LBMOLE ETA23    =  .964251E+00
          G3       =  .157796E+01              MW3      =  .721149E+01 LBM/LBMOLE
          M3       =  .157029E+00              P3       =  .208816E+03 TORR
          P30      =  .212914E+03 TORR         R3       =  .176100E-04 GM/CM3
          R30      =  .178283E-04 GM/CM3       T3       =  .137123E+04 K
          T30      =  .138100E+04 K            W3W1     =  .100000E+01
          X3X1     =  .100000E+01

POINT 4  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SECONDARY NOZZLF EXIT

          A4       =  .849544E+03 S-IN2/LBMOLE G4       =  .157796E+01
          MW4      =  .721149E+01 LBM/LBMOLE   M4       =  .775000E+00
          P4       =  .137590E+03 TORR         P40      =  .212914E+03 TORR
          R4       =  .135215E-04 GM/CM3       R40      =  .178283E-04 GM/CM3
          T4       =  .117676E+04 K            T40      =  .138100E+04 K
          W4W1     =  .100000E+01              X4X1     =  .100000E+01

POINT 5  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR PRIMARY NOZZLE FXIT

          A5       =  .275282E+03 S-IN2/LBMOLE G5       =  .129000E+01
          MW5      =  .202040E+02 LBM/LBMOLE   M5       =  .385905E+01
          P5       =  .139465E+03 TORR         P50      =  .450000E+03 PSIA
          R5       =  .507143E-06 GM/CM3       R50      =  .267851E-02 GM/CM3
          T5       =  .890936E+03 K            T50      =  .281480E+04 K
          W5W1     =  .284443E+01              X5X1     =  .101527E+01
```

```
POINT 6  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR EXIT AND SUBSONIC
         DIFFUSER ENTRANCE

         A6      =  .112483E+04 S-IN2/LBMOLE G6      =  .138524E+01
         MW6     =  .137570E+02 LBM/LBMOLE   M6      =  .482248E+00
         P6      =  .674846E+03 TORR         P60     =  .790020E+03 TORR
         R6      =  .683803E-04 GM/CM3       R60     =  .766185E-04 GM/CM3
         T6      =  .217707E+04 K            T60     =  .227459E+04 K
         W6W1    =  .384443E+01              X6X1    =  .201527E+01

POINT 7  SUBSONIC DIFFUSER EXIT

         A7      =  .337448E+04 S-IN2/LBMOLE ETA67   =  .975871E+00
         G7      =  .138524E+01              MW7     =  .137570E+02 LBM/LBMOLE
         M7      =  .142052E+00              P7      =  .760000E+03 TORR
         P70     =  .770958E+03 TORR         R7      =  .739935E-04 GM/CM3
         R70     =  .747698E-04 GM/CM3       T7      =  .226579E+04 K
         T70     =  .227459E+04 K            W7W1    =  .384443E+01
         X7X1    =  .201527E+01
```

```
                           SYSTEM CALCULATION SECTION

                                 INITIAL DATA:

EREACT  =   IRFNA/MMH                  NBANK   =            1
NEJECT  =           1                  RTIME   =   .600000E+02 S
WPP3    =  .183645E+04 GM/S

                           REACTANT STORAGE METHOD

 REACT        C2H4        HE                        NF3         D2
 PHASE        GAS         GAS                       GAS         GAS
 CONT         SPH         SPH                       SPH         SPH
 STEMP        300.0 K     300.0 K                   300.0 K     300.0 K
 STIME        INFINITE    INFINITE                  INFINITE    INFINITE

 SPRES        4.1E+07 PA  4.1E+07 PA                1.2E+07 PA  4.1E+07 PA
              (6000 PSI)  (6000 PSI)                (1800 PSI)  (6000 PSI)
 RFSYS        BLD         BLD                       BLD         BLD
 MATER        TI          TI                        SS          TI

 REACT        N2-AW       H2O-CS      MMH           IRFNA
 PHASE        GAS         LIQ         LIQ           LIQ
 CONT         SPH         SPH         SPH           SPH
 STEMP        300.0 K     300.0 K     300.0 K       300.0 K
 STIME        INFINITE    INFINITE    INFINITE      INFINITE

 SPRES        4.1E+07 PA  2.8E+06 PA  1.25*P0       1.25*P0
              (6000 PSI)  (400 PSI)
 RFSYS        BLD         PGS         PGS           PGS
 MATER        TI          TI          TI            AL

                                RESULTANT DATA:

                            SYSTEM SCALE-UP FACTOR

XLP     =  .901567E-03 GMOLE/S

                        LASER DEVICE SYSTEM VOLUME/MASS

MINJ    =  .110800E+03 LBM
MCB     =  .184169E+03 LBM
MBASE   =  .173223E+03 LBM          VCOMB    =  .209271E+01 FT3
MCAV    =  .511697E+02 LBM          VCAV     =  .194141E+01 FT3
MAW     =  .318450E+02 LBM          VAW      =  .382311E+00 FT3
MCS     =  .138112E+04 LBM          VCS      =  .223958E+02 FT3
MOPT    =  .253349E+04 LBM          VOPT     =  .379538E+02 FT3
MDS     =  .305286E+03 LBM
MLRREG  =  .147504E+03 LBM
MLLINE  =  .571152E+02 LBM
           -----------                           -----------
MLDHDW  =  .497572E+04 LBM          VLDHDW   =  .647661E+02 FT3
MLRT    =  .200252E+05 LBM          VLRT     =  .469017E+03 FT3
           -----------                           -----------
MLDS    =  .250009E+05 LBM          VLDS     =  .533763E+03 FT3
```

```
                      PRESSURE RECOVERY SYSTEM VOLUME/MASS

   MSUPD    =  .552167E+03 LBM              VSUPD    =  .181079E+02 FT3
   MSUBD    =  .207613E+03 LBM              VSUBD    =  .825893E+02 FT3
   MEJECT   =  .344220E+05 LBM              VEJECT   =  .358006E+04 FT3
   MERREG   =  .262238E+03 LBM
   MELINE   =  .148921E+02 LBM
               -----------                              -----------
   MPRHDW   =  .354589E+05 LBM              VPRHDW   =  .360643E+04 FT3
   MFRT     =  .898504E+04 LBM              VERT     =  .137762E+03 FT3
               -----------                              -----------
   MPRS     =  .444439E+05 LBM              VPRS     =  .374419E+04 FT3

                        SYSTEM VOLUME/MASS SUMMARY

   MLDS     =  .250009E+05 LBM              VLDS     =  .533783E+03 FT3
   MPRS     =  .444439E+05 LBM              VPRS     =  .374419E+04 FT3
   MMISC    =  .800000E+03 LBM
               -----------                              -----------
   MTOTAL   =  .702448E+05 LBM              VTOTAL   =  .427797E+04 FT3
                                            VSYSTM   =  .855595E+04 FT3

   WBASE    =  .587323E+03 IN               LLDS     =  .747789E+01 IN
   LPRS     =  .132803E+04 IN

   LAXDEV   =  .133551E+04 IN               WBXDEV   =  .646055E+03 IN
   HAXDEV   =  .169375E+03 IN               VBXDEV   =  .845712E+05 FT3
```

SAMPLE CASE 21 INPUT

```
ARE NEW COMBUSTION CHEMISTRY INPUTS REQUIRED?

YES

SHOULD INPUT DATA BE READ FROM TAPE1?

NO
```

```
SELECT THE LASER CHEMISTRY FROM THE FOLLOWING LIST:

"DF" FOR A DF CHEMICAL LASER
"HF" FOR A HF CHEMICAL LASER

DF
```

```
INPUT DATA FOR THE COMBUSTION CHEMISTRY SECTION BY NAMELIST.
CURRENT VALUES ARE:

$NLCCS                  AEXP    =  .361935E-02 ALPHA   =  .802700E+00
N1      =            2  N2      =            4 N3      =            1
N4      =            3  WPG     = 0.           WPR1    =  .362160E-02
WPR2    =  .172416E-01  WPR3    = 0.           WPR4    =  .571093E-01
WSR1    =  .437250E-02  WSR2    =  .338518E-01 WSR3    = 0.           $

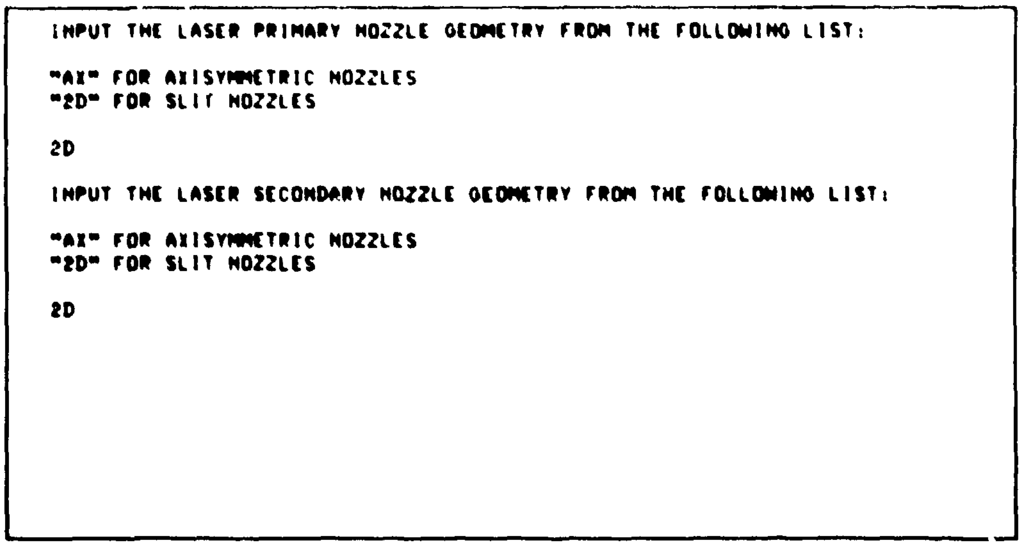
 $NLCCS WPG=0.116197E-02 $
```

```
ARE NEW LASER DEVICE INPUTS REQUIRED?

YES

SHOULD INPUT DATA BE READ FROM TAPE2?

NO
```



```
INPUT THE LASER PRIMARY NOZZLE GEOMETRY FROM THE FOLLOWING LIST:

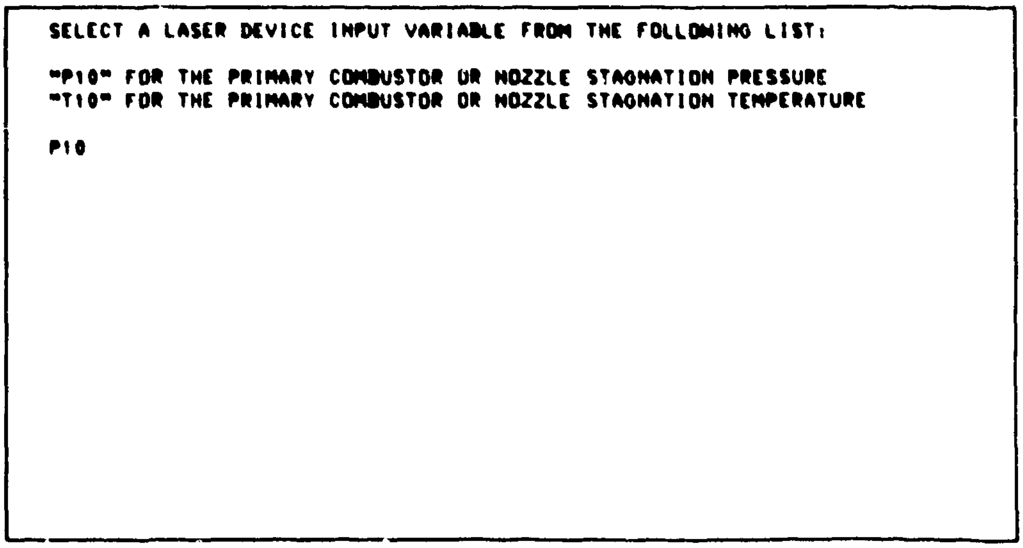
"AX" FOR AXISYMMETRIC NOZZLES
"2D" FOR SLIT NOZZLES

2D

INPUT THE LASER SECONDARY NOZZLE GEOMETRY FROM THE FOLLOWING LIST:

"AX" FOR AXISYMMETRIC NOZZLES
"2D" FOR SLIT NOZZLES

2D
```



```
SELECT A LASER DEVICE INPUT VARIABLE FROM THE FOLLOWING LIST:

"P10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION PRESSURE
"T10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE

P10
```

```
INPUT DATA FOR THE LASER DEVICE SECTION BY NAMELIST
CURRENT VALUES ARE:

$NLLDS                    BRFRAC  =  .100000E+01  CANGLE  =  .174533E+00
D1      =  .177800E-02   D1S     =  .669534E-04  D3      =  .137160E-02
D3S     =  .685800E-04   HBASE   =  .349250E-01  HNB     =  .349250E-01
LCAV    =  .762000E-01   LPNOZ   =  .250190E-02  LSNOZ   =  .185166E-02
NSPNOZ  =  .103846E+01   PKFRAC  =  .803431E+00  P10     =  .192105E+07
T30     =  .600000E+03   T70     =  .300000E+03 $

 $NLLDS P10=0.2E+07 $
```

```
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
NOTE: T10 =  .175525E+04 K   P10 =  .200000E+07 PA
```

```
ARE NEW PRESSURE RECOVERY INPUTS REQUIRED?

YES

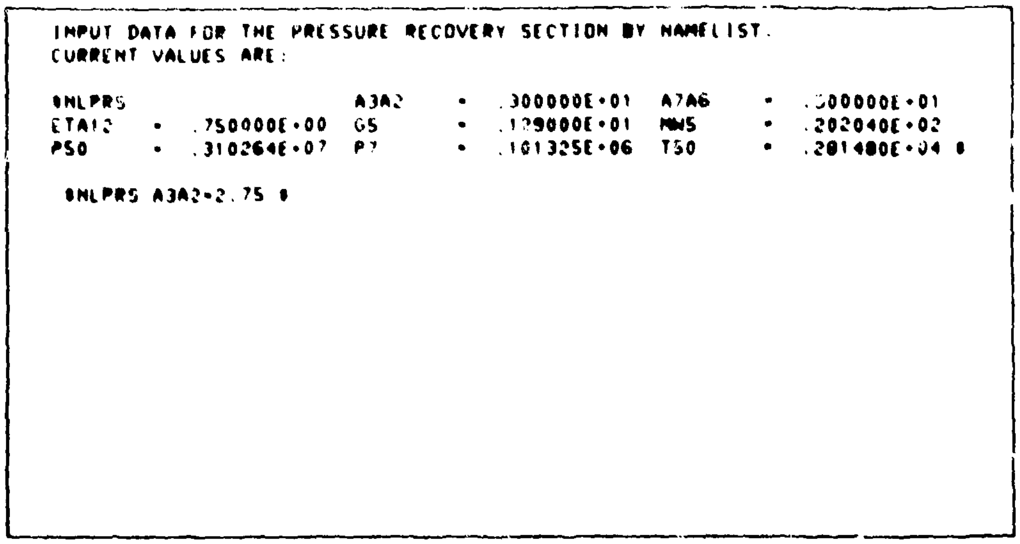
SHOULD INPUT DATA BE READ FROM TAPE3?

NO
```

```
INPUT THE PRESSURE RECOVERY SUBSYSTEM FROM THE FOLLOWING LIST:

"NO"  FOR NO PRESSURE RECOVERY SUBSYSTEM
"DIF" FOR A SUPERSONIC-SUBSONIC DIFFUSER SUBSYSTEM
"CAE" FOR A CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SUBSYSTEM
"SSE" FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR SUBSYSTEM

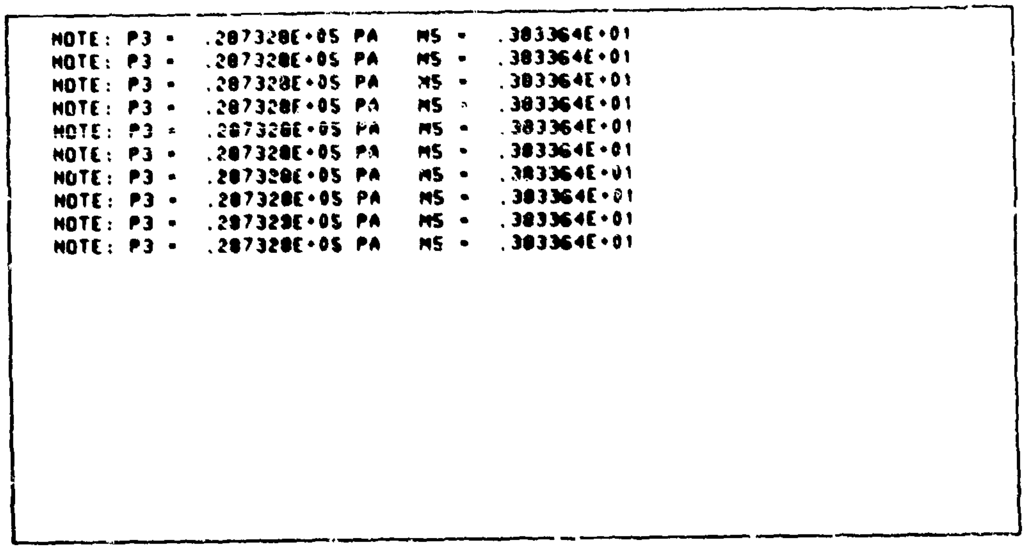
CAE
```



```
INPUT DATA FOR THE PRESSURE RECOVERY SECTION BY NAMELIST.
CURRENT VALUES ARE:

$NLPRS                    A3A2    =  .300000E+01  A7A6    =  .300000E+01
ETA12   =  .750000E+00    GS      =  .129000E+01  MW5     =  .202040E+02
PS0     =  .310264E+07    P7      =  .101325E+06  T50     =  .281480E+04 $

 $NLPRS A3A2=2.75 $
```



```
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
NOTE: P3 =  .287328E+05 PA   MS =  .383364E+01
```

```
ARE NEW SYSTEM CALCULATION INPUTS REQUIRED?

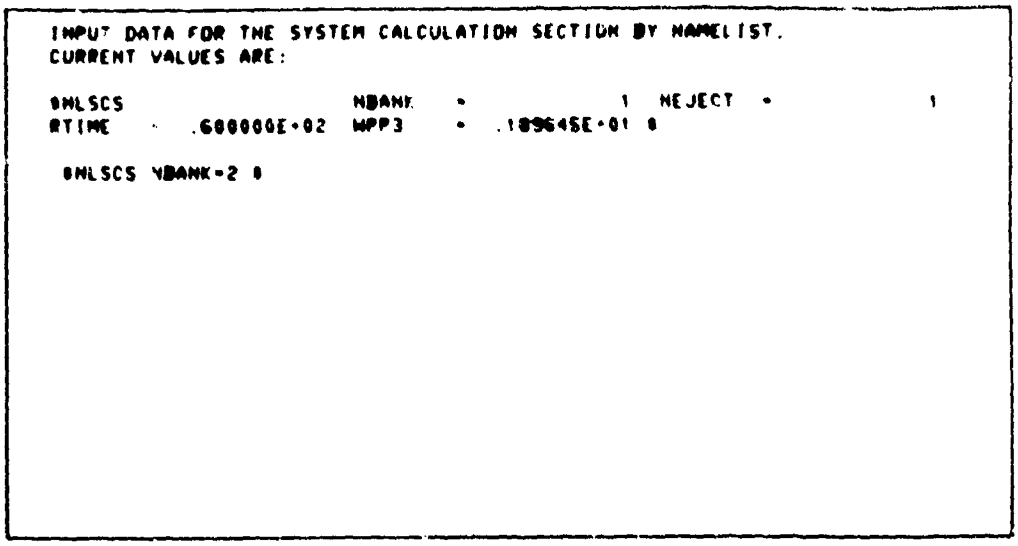
YES
```

```
ARE SYSTEM CALCULATIONS DESIRED?

YES

SHOULD INPUT DATA BE READ FROM TAPE4?

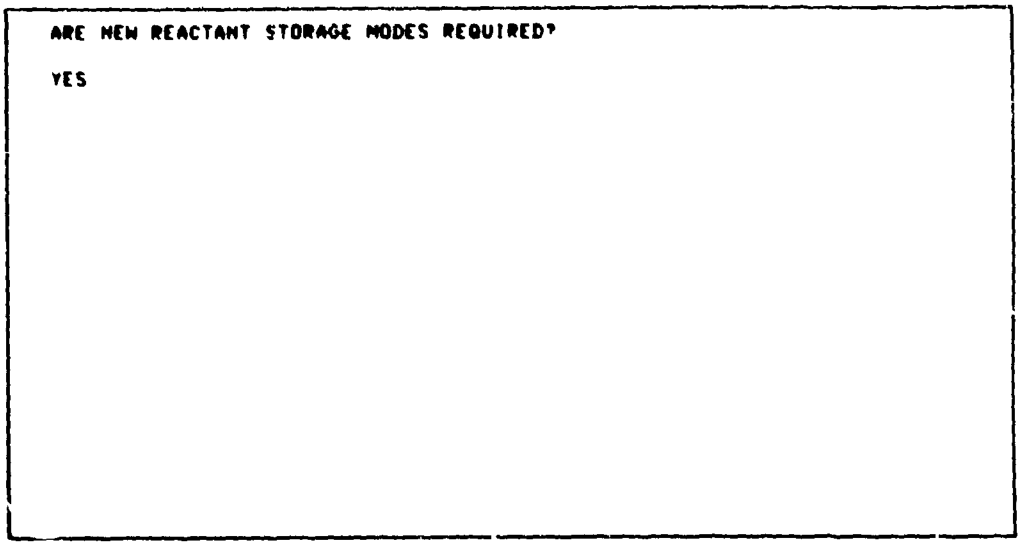
NO
```



```
INPUT DATA FOR THE SYSTEM CALCULATION SECTION BY NAMELIST.
CURRENT VALUES ARE:

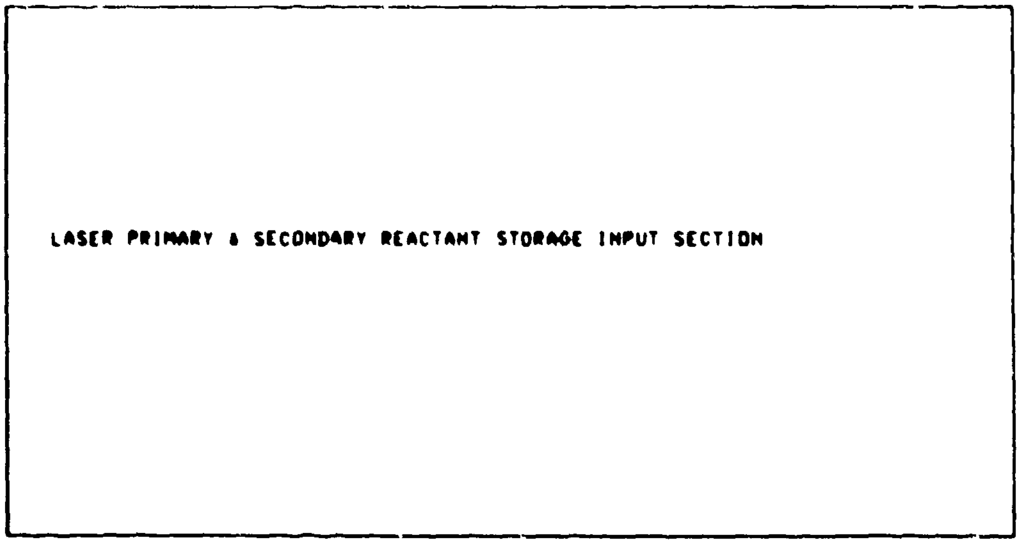
$NLSCS                   NBANK   =              1  NEJECT  =              1
RTIME    =   .600000E+02  WPP3    =  .189645E+01 $

 $NLSCS NBANK=2 $
```

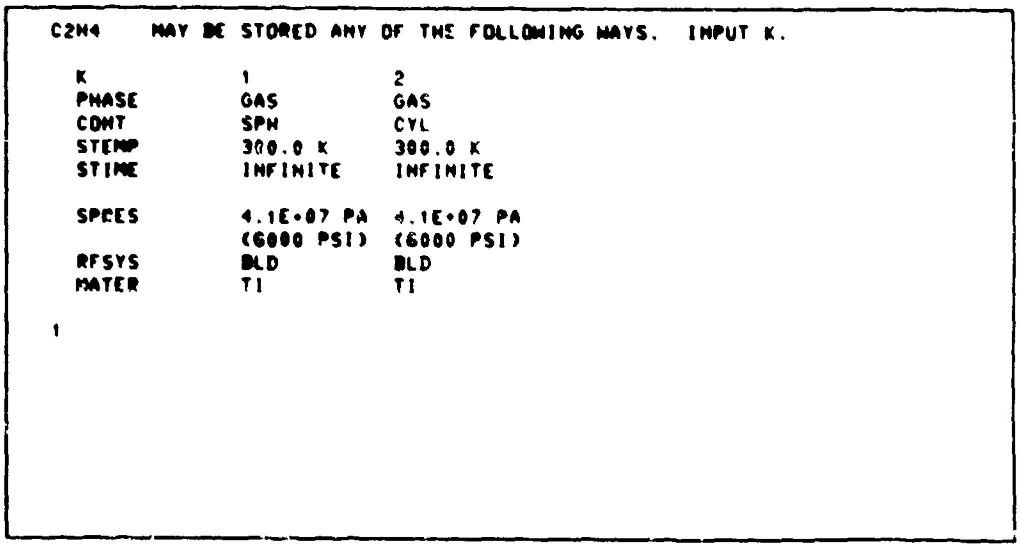


```
ARE NEW REACTANT STORAGE MODES REQUIRED?

YES
```



```
LASER PRIMARY & SECONDARY REACTANT STORAGE INPUT SECTION
```

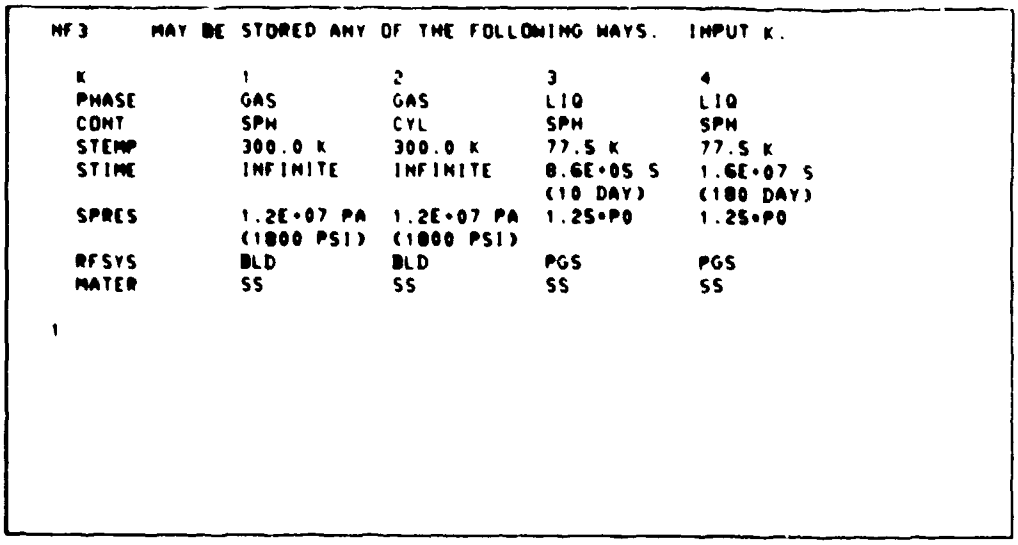


```
C2H4    MAY BE STORED ANY OF THE FOLLOWING WAYS.  INPUT K.

  K          1            2
  PHASE      GAS          GAS
  CONT       SPH          CYL
  STEMP      300.0 K      300.0 K
  STIME      INFINITE     INFINITE

  SPRES      4.1E+07 PA   4.1E+07 PA
             (6000 PSI)   (6000 PSI)
  RFSYS      BLD          BLD
  MATER      TI           TI

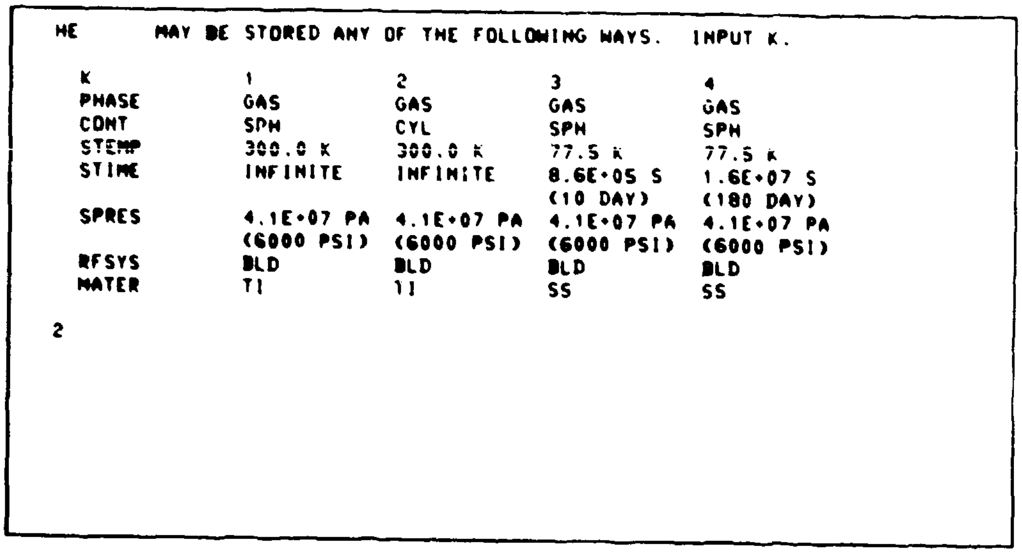
1
```



```
NF3      MAY BE STORED ANY OF THE FOLLOWING WAYS.  INPUT K.

   K            1            2            3            4
   PHASE        GAS          GAS          LIQ          LIQ
   CONT         SPH          CYL          SPH          SPH
   STEMP        300.0 K      300.0 K      77.5 K       77.5 K
   STIME        INFINITE     INFINITE     8.6E+05 S    1.6E+07 S
                                          (10 DAY)     (180 DAY)
   SPRES        1.2E+07 PA   1.2E+07 PA   1.25*P0      1.25*P0
                (1800 PSI)   (1800 PSI)
   RFSYS        BLD          BLD          PGS          PGS
   MATER        SS           SS           SS           SS

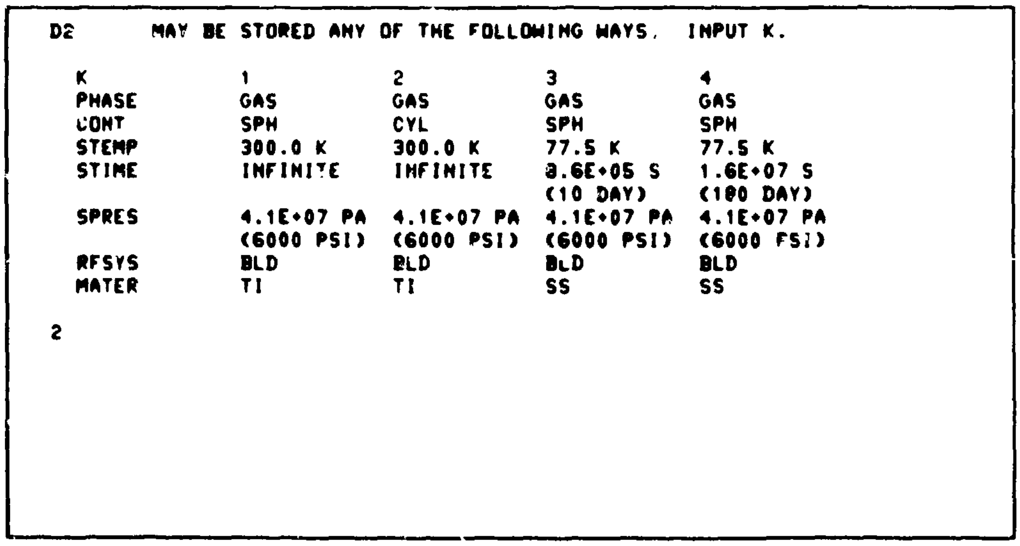
1
```



```
HE       MAY BE STORED ANY OF THE FOLLOWING WAYS.  INPUT K.

   K            1            2            3            4
   PHASE        GAS          GAS          GAS          GAS
   CONT         SPH          CYL          SPH          SPH
   STEMP        300.0 K      300.0 K      77.5 K       77.5 K
   STIME        INFINITE     INFINITE     8.6E+05 S    1.6E+07 S
                                          (10 DAY)     (180 DAY)
   SPRES        4.1E+07 PA   4.1E+07 PA   4.1E+07 PA   4.1E+07 PA
                (6000 PSI)   (6000 PSI)   (6000 PSI)   (6000 PSI)
   RFSYS        BLD          BLD          BLD          BLD
   MATER        TI           TI           SS           SS

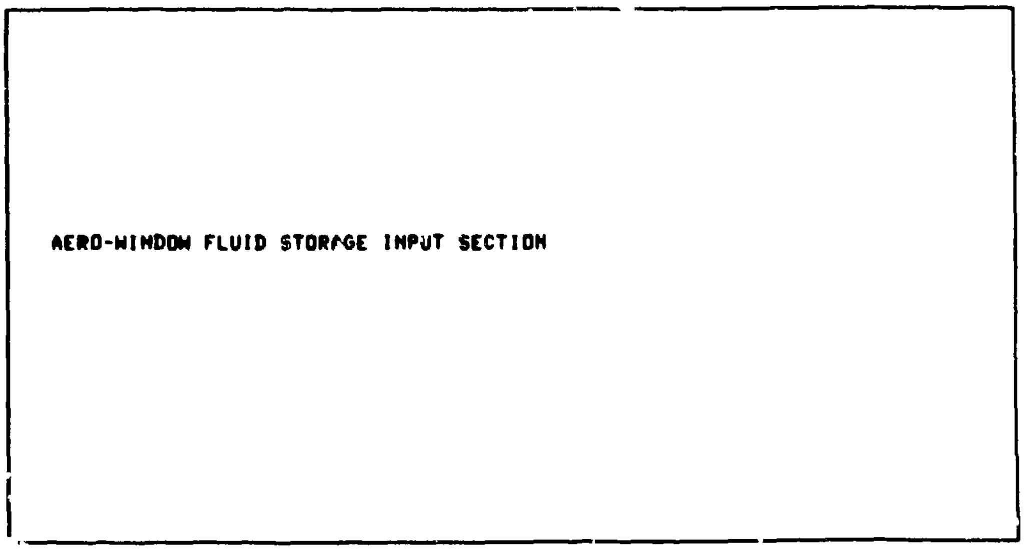
2
```



```
D2      MAY BE STORED ANY OF THE FOLLOWING WAYS.  INPUT K.

  K            1            2            3            4
  PHASE        GAS          GAS          GAS          GAS
  CONT         SPH          CYL          SPH          SPH
  STEMP        300.0 K      300.0 K      77.5 K       77.5 K
  STIME        INFINITE     INFINITE     8.6E+05 S    1.6E+07 S
                                         (10 DAY)     (100 DAY)
  SPRES        4.1E+07 PA   4.1E+07 PA   4.1E+07 PA   4.1E+07 PA
               (6000 PSI)   (6000 PSI)   (6000 PSI)   (6000 PSI)
  RFSYS        BLD          BLD          BLD          BLD
  MATER        TI           TI           SS           SS

2
```



```
AERO-WINDOW FLUID STORAGE INPUT SECTION
```

```
N2-AN   MAY BE STORED ANY OF THE FOLLOWING WAYS.  INPUT K.

  K             1            2            3            4
  PHASE         GAS          GAS          LIQ          LIQ
  CONT          SPH          CYL          SPH          SPH
  STEMP         300.0 K      300.0 K      77.5 K       77.5 K
  STIME         INFINITE     INFINITE     8.6E+05 S    1.6E+07 S
                                          (10 DAY)     (180 DAY)
  SPRES         4.1E+07 PA   4.1E+07 PA   1.5E+06 PA   1.5E+06 PA
                (6000 PSI)   (6000 PSI)   (220 PSI)    (220 PSI)
  RFSYS         BLD          BLD          HPS          HPS
  MATER         TI           TI           SS           SS

1
```

```
COOLING SYSTEM FLUID STORAGE INPUT SECTION
```

```
H2O-CS  MAY BE STORED ANY OF THE FOLLOWING WAYS.  INPUT K.

  K            1            2            3            4
  PHASE        LIQ          LIQ          LIQ          LIQ
  CONT         SPH          CYL          SPH          CYL
  STEMP        300.0 K      300.0 K      300.0 K      300.0 K
  STIME        INFINITE     INFINITE     INFINITE     INFINITE

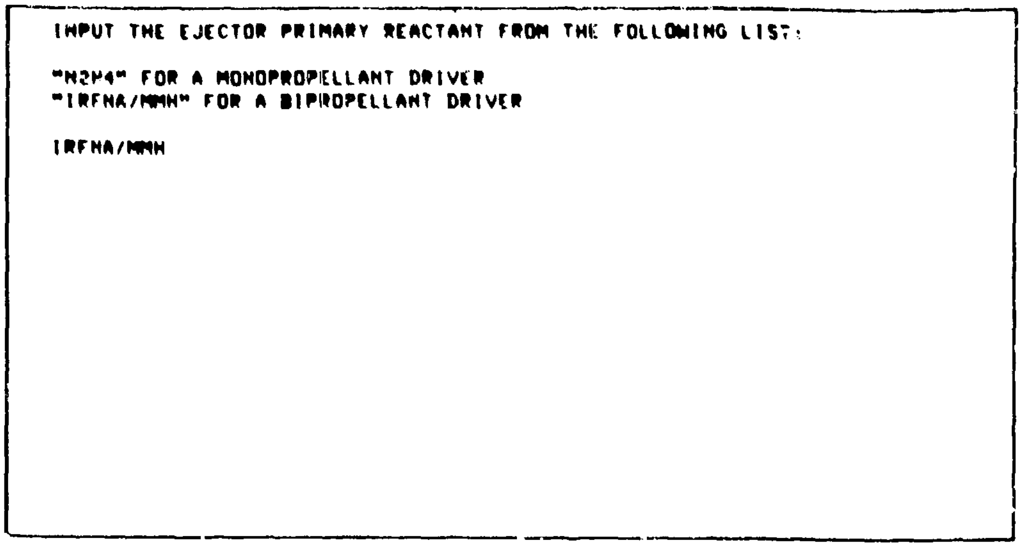
  SPRES        2.8E+06 PA   2.8E+06 PA   1 ATM        1 ATM
               (400 PSI)    (300 PSI)
  RFSYS        POS          POS          PFS          PFS
  MATER        TI           TI           AL           AL
```

```
  K            5
  PHASE        LIQ
  CONT         SPH
  STEMP        300-300 K
  STIME        INFINITE

  SPRES        1 ATM

  RFSYS        RFP
  MATER        AL

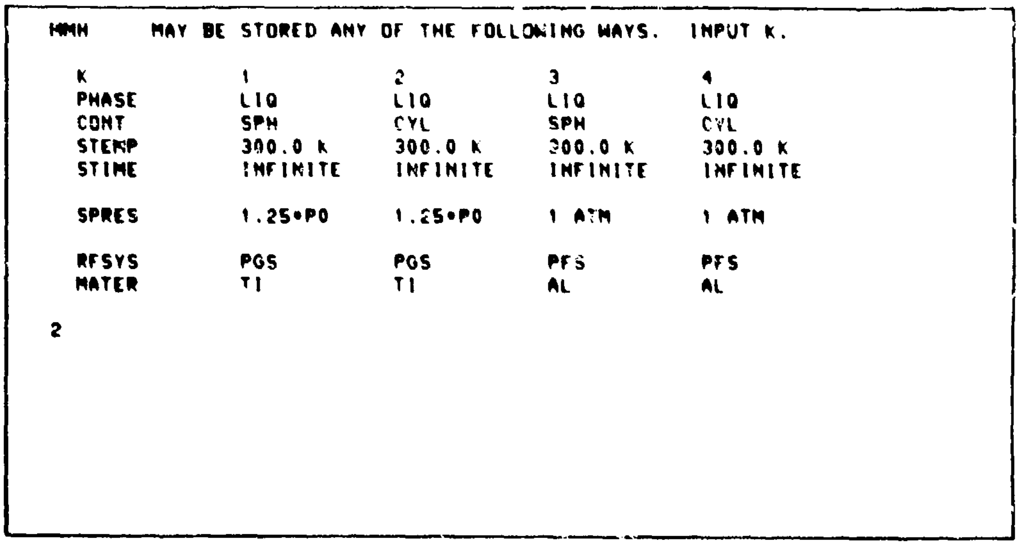
5
```



```
INPUT THE EJECTOR PRIMARY REACTANT FROM THE FOLLOWING LIST:

"N2H4" FOR A MONOPROPELLANT DRIVER
"IRFNA/MMH" FOR A BIPROPELLANT DRIVER

IRFNA/MMH
```



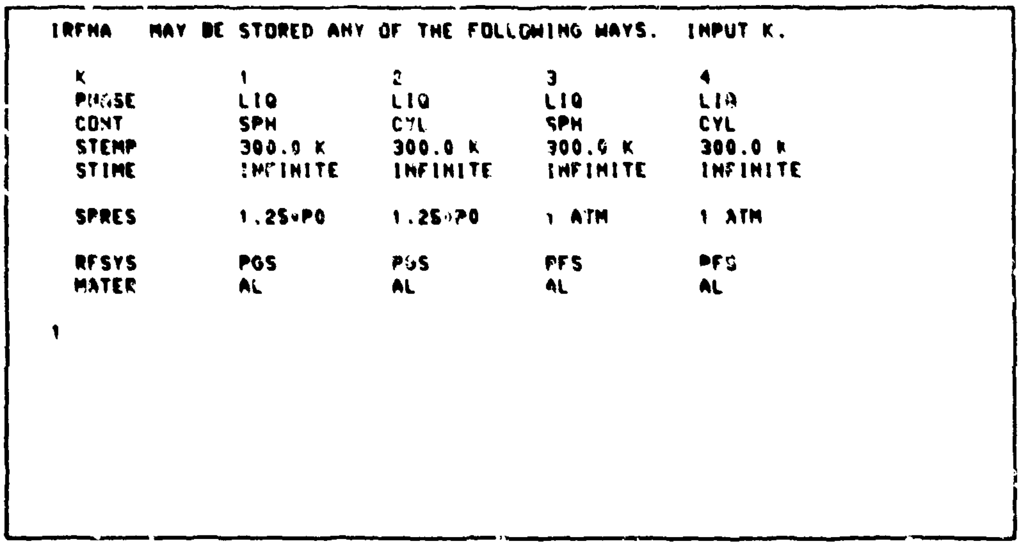
```
MMH      MAY BE STORED ANY OF THE FOLLOWING WAYS.  INPUT K.

  K           1           2           3           4
  PHASE       LIQ         LIQ         LIQ         LIQ
  CONT        SPH         CYL         SPH         CYL
  STEMP       300.0 K     300.0 K     300.0 K     300.0 K
  STIME       INFINITE    INFINITE    INFINITE    INFINITE

  SPRES       1.25*PO     1.25*PO     1 ATM       1 ATM

  RFSYS       PGS         PGS         PFS         PFS
  MATER       TI          TI          AL          AL

2
```



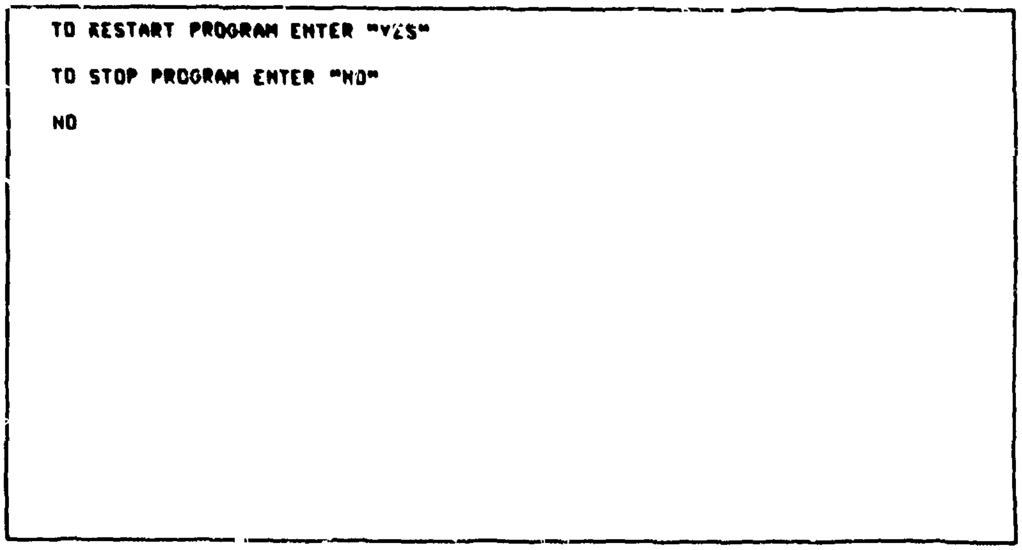
```
IRFNA   MAY BE STORED ANY OF THE FOLLOWING WAYS.  INPUT K.

  K           1           2           3           4
  PHASE       LIQ         LIQ         LIQ         LIQ
  CONT        SPH         CYL         SPH         CYL
  STEMP       300.0 K     300.0 K     300.0 K     300.0 K
  STIME       INFINITE    INFINITE    INFINITE    INFINITE

  SPRES       1.25*P0     1.25*P0     1 ATM       1 ATM

  RFSYS       POS         POS         PFS         PFS
  MATER       AL          AL          AL          AL

1
```



```
TO RESTART PROGRAM ENTER "YES"

TO STOP PROGRAM ENTER "NO"

NO
```

SAMPLE CASE 2: OUTPUT (SI UNITS)

```
                      CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

                          WRITTEN BY: C.L. ADAMS
                                      A.L. ADDY
                                      R.D. MASSEY
                                      C.D. MIKKELSEN
                                      G.F. MORR
                                      R.L. OBLUKIAN
                                      B.J. WALKER

                                 1 JANUARY 77

                        AERODYNAMICS GROUP (DRDMI-TDK)
                        SYSTEM SIMULATION DIRECTORATE
                 U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
                        REDSTONE ARSENAL, ALABAMA 35809

                              RUN DATE  12/06/78


                          COMBUSTION CHEMISTRY SECTION

                                 INITIAL DATA:

    AEXP     =  .361935E-02 M2           ALPHA    =  .802700E+00
    DFORHF   =   DF                      N1       =              2 ATOMS C
    N2       =              4 ATOMS H    N3       =              1 ATOMS N
    N4       =              3 ATOMS F    WPG      =  .116197E-02 KG/S N2
    WPR1     =  .362160E-02 KG/S C2H4    WPR2     =  .172416E-01 KG/S HE
    WPR3     = 0.           KG/S N2      WPR4     =  .571093E-01 KG/S N1F3
    WSR1     =  .437250E-02 KG/S D2      WSR2     =  .338518E-01 KG/S HE
    WSR3     = 0.           KG/S N2

                                RESULTANT DATA:

    FDAA     =  .191592E+00 KMOLE/S-M2 OMEGA    =  .347901E+02
    OMEGTRW  =  .322770E+02              PSIC     =  .126969E+02
    PSIL     =  .220931E+02              PSILTRW  =  .195801E+02
    Q        =  .218542E+08 J/KMOLE      RC       =  .207688E+01
    RL       =  .251301E+01              RLP      =  .220931E+02

    WFCP1    =  .193609E+00 CF4          XFCP1    =  .159827E-01 CF4
    WFCP2    =  .880274E-01 HF           XFCP2    =  .319653E-01 HF
    WFCP3    =  .154674E+00 DF           XFCP3    =  .534772E-01 DF
    WFCP4    =  .435361E+00 HE           XFCP4    =  .790200E+00 HE
    WFCP5    =  .105898E+00 N2           XFCP5    =  .274632E-01 N2
    WFCP6    =  .224317E-01 D            XFCP6    =  .809116E-01 D
```

```
                              LASER DEVICE SECTION

                                 INITIAL DATA:

        ARFRAC   =  .100000E+01               CANGLE   =  .174533E+00 RAD
        D1       =  .177800E-02 M             D1S      =  .669534E-04 M
        D3       =  .137160E-02 M             D3S      =  .685800E-04 M
        GEOMPN   =   2D                       GEOMSN   =   2D
        HBASE    =  .349250E-01 M             HNB      =  .349250E-01 M
        LCAV     =  .762000E-01 M             LPNOZ    =  .250190E-02 M
        LSNOZ    =  .185166E-02 M             NSPNOZ   =  .103846E+01
        PKFRAC   =  .803431E+00               P10      =  .200000E+07 PA
        T30      =  .600000E+03 K             T70      =  .300000E+03 K

                                RESULTANT DATA:

POINT 1  PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION
         (COMBUSTOR) TEMPERATURE

        A1       =  .171526E+00 S-M2/KMOLE A1A1SE   =  .176697E+02
        A1A1SG   =  .265558E+02               G1       =  .145759E+01
        MW1      =  .124497E+02 KG/KMOLE      M1       =  .486705E+01
        NPNOZ    =  .415138E+04 S/KMOLE       P1       =  .523849E+04 PA
        P10      =  .200000E+07 PA            RE1      =  .213634E+04
        R1       =  .288884E-01 KG/M3         R10      =  .170617E+01 KG/M3
        T1       =  .271528E+03 K             T10      =  .175525E+04 K

POINT 2  PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT
         TEMPERATURE

        A2       =  .156421E+00 S-M2/KMOLE G2       =  .153454E+01
        MW2      =  .124497E+02 KG/KMOLE      M2       =  .488705E+01
        P2       =  .523849E+04 PA            P20      =  .200000E+07 PA
        R2       =  .288884E-01 KG/M3         R20      =  .170617E+01 KG/M3
        T2       =  .271528E+03 K             T20      =  .175525E+04 K

POINT 3  SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION
         (COMBUSTOR) TEMPERATURE

        A3       =  .135591E+00 S-M2/KMOLE A3A3SE   =  .131315E+02
        A3A3SG   =  .200000E+02               G3       =  .161679E+01
        MW3      =  .400551E+01 KG/KMOLE      M3       =  .530231E+01
        NSNOZ    =  .431104E+04 S/KMOLE       P3       =  .239593E+04 PA
        P30      =  .917516E+06 PA            RE3      =  .187829E+04
        R3       =  .186036E-01 KG/M3         R30      =  .736704E+00 KG/M3
        T3       =  .620454E+02 K             T30      =  .600000E+03 K
        W3W1     =  .490228E+00               X3X1     =  .152370E+01

POINT 4  SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT
         TEMPERATURE

        A4       =  .136095E+00 S-M2/KMOLE G4       =  .161322E+01
        MW4      =  .400551E+01 KG/KMOLE      M4       =  .530231E+01
        P4       =  .239593E+04 PA            P40      =  .917516E+06 PA
        R4       =  .186036E-01 KG/M3         R40      =  .736704E+00 KG/M3
        T4       =  .620454E+02 K             T40      =  .600000E+03 K
        W4W2     =  .490228E+00               X4X2     =  .152370E+01
```

```
POINT 5  CONSTANT-AREA MIXING REGION EXIT

         A5        =  .292516E+00 S-M2/KMOLE G5        =  .157943E+01
         MW5       =  .735148E+01 KG/KMOLE   M5        =  .486401E+01
         P5        =  .409570E+04 PA         P50       =  .112781E+07 PA
         R5        =  .262852E-01 KG/M3      R50       =  .921547E+00 KG/M3
         T5        =  .137773E+03 K          T50       =  .108210E+04 K
         W5W2      =  .149023E+01            X5X2      =  .252370E+01
POINT 6  ISENTROPIC EXPANSION REGION EXIT

         A6        =  .577895E+00 S-M2/KMOLE G6        =  .157943E+01
         MW6       =  .735148E+01 KG/KMOLE   M6        =  .610993E+01
         P6        =  .134559E+04 PA         P60       =  .112781E+07 PA
         R6        =  .129910E-01 KG/M3      R60       =  .921547E+00 KG/M3
         T6        =  .915840E+02 K          T60       =  .108210E+04 K
         W6W2      =  .149023E+01            X6X2      =  .252370E+01
POINT 7  MIRROR PURGE CONDITIONS

         G7        =  .139962E+01            MW7       =  .280134E+02 KG/KMOLE
         T70       =  .300000E+03 K          W7W2      =  .149023E-01
         X7X2      = 0.

POINT 8  LASER CAVITY EXIT

         A8        =  .102254E+01 S-M2/KMOLE G8        =  .157692E+01
         MW8       =  .726491E+01 KG/KMOLE   M8        =  .228388E+01
         P8        =  .517077E+04 PA         P80       =  .636011E+05 PA
         RE8       =  .375835E+05            R8        =  .788141E-02 KG/M3
         R80       =  .387849E-01 KG/M3      T8        =  .573263E+03 K
         T80       =  .143582E+04 K          W8W2      =  .150513E+01
         X8X2      =  .257931E+01
```

```
APPENDIX [illegible]                    CLAP SAMPLE INPUT/OUTPUT

                                        PRESSURE RECOVERY SECTION

                                            INITIAL DATA:

         A3A2     =  .275000E+01                   A7A6     =  .300000E+01
         EJECT    =   CAE                          ETA12    =  .750000E+00
         G5       =  .129000E+01                   MW5      =  .202040E+02 KG/KMOLE
         P50      =  .310264E+07 PA                P7       =  .101325E+06 PA
         T50      =  .281480E+04 K

                                           RESULTANT DATA:

POINT 1  LASER CAVITY EXIT AND NORMAL SHOCK DIFFUSER ENTRANCE

         A1       =  .102254E+01 S-M2/KMOLE G1       =  .157692E+01
         MW1      =  .726491E+01 KG/KMOLE   M1       =  .228388E+01
         P1       =  .517077E+04 PA         P10      =  .636011E+05 PA
         R1       =  .788141E-02 KG/M3      R10      =  .387049E-01 KG/M3
         T1       =  .573263E+03 K          T10      =  .143582E+04 K

POINT 2  NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DIFFUSER ENTRANCE

         A2       =  .102254E+01 S-M2/KMOLE ETA12    =  .750000E+00
         G2       =  .157692E+01               MW2      =  .726491E+01 KG/KMOLE
         M2       =  .561754E+00               P2       =  .238891E+05 PA
         P20      =  .303123E+05 PA         R2       =  .158612E-01 KG/M3
         R20      =  .184468E-01 KG/M3      T2       =  .131603E+04 K
         T20      =  .143582E+04 K          W2W1     =  .100000E+01
         X2X1     =  .100000E+01

POINT 3  SUBSONIC DIFFUSER EXIT AND SUDDEN ENLARGEMENT ENTRANCE

         A3       =  .281199E+01 S-M2/KMOLE ETA23    =  .969997E+00
         G3       =  .157692E+01               MW3      =  .726491E+01 KG/KMOLE
         M3       =  .171354E+00               P3       =  .287328E+05 PA
         P30      =  .294029E+05 PA         R3       =  .176336E-01 KG/M3
         R30      =  .178933E-01 KG/M3      T3       =  .142376E+04 K
         T30      =  .143582E+04 K          W3W1     =  .100000E+01
         X3X1     =  .100000E+01

POINT 4  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SECONDARY NOZZLE EXIT

         A4       =  .119781E+01 S-M2/KMOLE G4       =  .157692E+01
         MW4      =  .726491E+01 KG/KMOLE   M4       =  .775000E+00
         P4       =  .190064E+05 PA         P40      =  .294029E+05 PA
         R4       =  .135704E-01 KG/M3      R40      =  .178933E-01 KG/M3
         T4       =  .122379E+04 K          T40      =  .143582E+04 K
         W4W1     =  .100000E+01               X4X1     =  .100000E+01

POINT 5  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR PRIMARY NOZZLE EXIT

         A5       =  .368370E+00 S-M2/KMOLE G5       =  .129000E+01
         MW5      =  .202040E+02 KG/KMOLE   M5       =  .383364E+01
         P5       =  .193543E+05 PA         P50      =  .310264E+07 PA
         R5       =  .523150E-01 KG/M3      R50      =  .267851E+01 KG/M3
         T5       =  .899001E+03 K          T50      =  .281480E+04 K
         W5W1     =  .272616E+01               X5X1     =  .980266E+00
```

```
POINT 6  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR EXIT AND SUBSONIC
         DIFFUSER ENTRANCE

         A6      =  .156618E+01 S-M2/KMOLE G6       =  .138726E+01
         MW6     =  .136700E+02 KG/KMOLE   M6       =  .485229E+00
         P6      =  .898218E+05 PA         P60      =  .105375E+06 PA
         R6      =  .676222E-01 KG/M3      R60      =  .758725E-01 KG/M3
         T6      =  .218390E+04 K          T60      =  .220346E+04 K
         W6W1    =  .372616E+01            X6X1     =  .198027E+01

POINT 7  SUBSONIC DIFFUSER EXIT

         A7      =  .469854E+01 S-M2/KMOLE ETA67    =  .975563E+00
         G7      =  .138726E+01            MW7      =  .136700E+02 KG/KMOLE
         M7      =  .142498E+00            P7       =  .101325E+06 PA
         P70     =  .102800E+06 PA         R7       =  .732439E-01 KG/M3
         R70     =  .740184E-01 KG/M3      T7       =  .227450E+04 K
         T70     =  .220346E+04 K          W7W1     =  .372616E+01
         X7X1    =  .198027E+01
```

```
                              SYSTEM CALCULATION SECTION

                                    INITIAL DATA:

          FREACT  =   IRFNA/MMH                 NBANK   =                2
          NEJECT  =              1              RTIME   =   .600000E+02 S
          WPP3    =  .189645E+01 KG/S

                               REACTANT STORAGE METHOD

           REACT       C2H4        HE                         NF3         D2
           PHASE       GAS         GAS                        GAS         GAS
           CONT        SPH         CYL                        SPH         CYL
           STEMP       300.0 K     300.0 K                    300.0 K     300.0 K
           STIME       INFINITE    INFINITE                   INFINITE    INFINITE

           SPRES       4.1E+07 PA 4.1E+07 PA                  1.2E+07 PA 4.1E+07 PA
                       (6000 PSI) (6000 PSI)                  (1800 PSI) (6000 PSI)
           RFSYS       BLD         BLD                        BLD         BLD
           MATER       TI          TI                         SS          TI

           REACT       N2-AW       H2O-CS      MMH            IRFNA
           PHASE       GAS         LIQ         LIQ            LIQ
           CONT        SPH         SPH         CYL            SPH
           STEMP       300.0 K     368-388 K   306.0 K        300.0 K
           STIME       INFINITE    INFINITE    INFINITE       INFINITE

           SPRES       4.1E+07 PA 1 ATM        1.25*P0        1.25*P0
                       (6000 PSI)
           RFSYS       BLD         RFP         PGS            PGS
           MATER       TI          AL          TI             AL

                                  RESULTANT DATA:

                               SYSTEM SCALE-UP FACTOR

          XLP     =  .901567E+00 KMOLE/S

                            LASER DEVICE SYSTEM VOLUME/MASS

          MINJ    =  .503787E+02 KG
          MCB     =  .855397E+02 KG
          MBASE   =  .785727E+02 KG          VCOMB    =  .592742E-01 M3
          MCAV    =  .232102E+02 KG          VCAV     =  .549746E-01 M3
          MAW     =  .288893E+02 KG          VAW      =  .216517E-01 M3
          MCS     =  .340163E+03 KG          VCS      =  .355570E+00 M3
          MOPT    =  .724745E+03 KG          VOPT     =  .198601E+01 M3
          MDS     =  .962447E+02 KG
          MLRREG  =  .669069E+02 KG
          MLLINE  =  .258933E+02 KG
                     -----------                         -----------
          MLDMOW  =  .152054E+04 KG          VLDMOW   =  .247748E+01 M3
          MLRT    =  .115267E+05 KG          VLRT     =  .134211E+02 M3
                     -----------                         -----------
          MLDS    =  .130472E+05 KG          VLDS     =  .158986E+02 M3
```

```
                    PRESSURE RECOVERY SYSTEM VOLUME/MASS

MSUPD   =  .250459E+03 KG          VSUPD   =  .512733E+00 M3
MSUBD   =  .941716E+02 KG          VSUBD   =  .233867E+00 M3
MEJECT  =  .104693E+05 KG          VEJECT  =  .695105E+02 M3
MERREG  =  .115147E+03 KG
MELINE  =  .759847E+01 KG
           -----------                         -----------
MPRHDW  =  .109367E+05 KG          VPRHDW  =  .702571E+02 M3
MERT    =  .397195E+04 KG          VERT    =  .377629E+01 M3
           -----------                         -----------
MPRS    =  .149086E+05 KG          VPRS    =  .740334E+02 M3

                       SYSTEM VOLUME/MASS SUMMARY

MLDS    =  .130472E+05 KG          VLDS    =  .158986E+02 M3
MPRS    =  .149086E+05 KG          VPRS    =  .740334E+02 M3
MMISC   =  .362874E+03 KG
           -----------                         -----------
MTOTAL  =  .283187E+05 KG          VTOTAL  =  .899320E+02 M3
                                   VSYSTM  =  .179864E+03 M3

WBASE   =  .745900E+01 M           LLDS    =  .189968E+00 M
LPRS    =  .238036E+02 M

LBXDEV  =  .239936E+02 M           WBXDEV  =  .820490E+01 M
HBXDEV  =  .601315E+01 M           VBXDEV  =  .118378E+04 M3
```

APPENDIX B   CLAP SAMPLE INPUT/OUTPUT

```
                         CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

                              WRITTEN BY: C.L. ADAMS
                                          A.L. ADDY
                                          R.D. MASSEY
                                          C.D. MIKKELSEN
                                          G.F. MORR
                                          R.L. OGLUKIAN
                                          R.J. WALKER

                                      1 JANUARY 77

                              AERODYNAMICS GROUP (DRDMI-TDK)
                              SYSTEM SIMULATION DIRECTORATE
                    U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
                              REDSTONE ARSENAL, ALABAMA 35809

                                   RUN DATE  12/06/78


                               COMBUSTION CHEMISTRY SECTION

                                      INITIAL DATA:

        AEXP    =  .361935E-02 M2          ALPHA   =  .802700E+00
        DFORHF  =   DF                     N1      =                2 ATOMS C
        N2      =              4 ATOMS H   N3      =                1 ATOMS N
        N4      =              3 ATOMS F   WPB     = 0.              KG/S N2
```

SAMPLE CASE 2: OUTPUT (ENGINEERING UNITS)

```
                         CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

                               WRITTEN BY: C.L. ADAMS
                                           A.L. ADDY
                                           R.D. MASSEY
                                           C.D. MIKKELSEN
                                           G.F. MORR
                                           R.L. OGLUKIAN
                                           B.J. WALKER

                                      1 JANUARY 77

                            AERODYNAMICS GROUP (DRDMI-TDK)
                            SYSTEM SIMULATION DIRECTORATE
                     U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
                            REDSTONE ARSENAL, ALABAMA 35809

                                  RUN DATE  12/06/78



                               COMBUSTION CHEMISTRY SECTION

                                      INITIAL DATA:

          AEXP     =  .561000E+01 IN2           ALPHA    =  .802700E+00
          DFORMF   =   DF                       N1       =             2 ATOMS C
          N2       =            4 ATOMS H       N3       =             1 ATOMS N
          N4       =            3 ATOMS F       WP6      =  .116197E+01 GM/S N2
          WPR1     =  .362160E+01 GM/S C2H4     WPR2     =  .172416E+02 GM/S HE
          WPR3     = 0.           GM/S N2       WPR4     =  .571093E+02 GM/S N1F3
          WSR1     =  .437250E+01 GM/S O2       WSR2     =  .338518E+02 GM/S HE
          WSR3     = 0.           GM/S N2

                                     RESULTANT DATA:

          PDAA     =  .123607E+00 GMOLE/S-IN2   OMEGA    =  .347901E+02
          OMEGTRW  =  .322770E+02               PSIC     =  .126969E+02
          PSIL     =  .220931E+02               PSILTRW  =  .195801E+02
          Q        =  .522329E+04 CAL/GMOLE     RC       =  .207688E+01
          RL       =  .251301E+01               RLF      =  .220931E+02

          WFCP1    =  .193609E+00 CF4           XPCP1    =  .159827E-01 CF4
          WFCP2    =  .880274E-01 HF            XPCP2    =  .319653E-01 HF
          WFCP3    =  .154674E+00 DF            XPCP3    =  .534772E-01 DF
          WFCP4    =  .435361E+00 HE            XPCP4    =  .790200E+00 HE
          WFCP5    =  .105898E+00 N2            XPCP5    =  .274632E-01 N2
          WFCP6    =  .224317E-01 D             XPCP6    =  .809116E-01 D
```

```
                                  LASER DEVICE SECTION

                                     INITIAL DATA:

          BRFRAC  =  .100000E+01                   CANGLE  =  .100000E+02 DEG
          D1      =  .700000E-01  IN               D1S     =  .263596E-02 IN
          D3      =  .540000E-01  IN               D3S     =  .270000E-02 IN
          GEOMPN  =   2D                           GEOMSN  =   2D
          HBASE   =  .137500E+01  IN               HNB     =  .137500E+01 IN
          LCAV    =  .300000E+01  IN               LPNOZ   =  .985000E-01 IN
          LSNOZ   =  .729000E-01  IN               NSPNOZ  =  .100846E+01
          PKFRAC  =  .803431E+00                   P10     =  .290075E+03 PSIA
          T30     =  .600000E+03 K                 T70     =  .300000E+03 K

                                    RESULTANT DATA:

POINT 1   PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION
          (COMBUSTOR) TEMPERATURE

          A1      =  .120594E+03 S-IN2/LBMOLE A1A1SE  =  .176697E+02
          A1A1SG  =  .265558E+02                B1      =  .145759E+01
          MW1     =  .124497E+02 LBM/LBMOLE     M1      =  .488705E+01
          NPNOZ   =  .188302E+04 S/LBMOLE       P1      =  .392919E+02 TORR
          P10     =  .290075E+03 PSIA           RE1     =  .21363[illegible]E+04
          R1      =  .288884E-04 GM/CM3         R10     =  .170617E-02 GM/CM3
          T1      =  .271528E+03 K              T10     =  .175525E+04 K

POINT 2   PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT
          TEMPERATURE

          A2      =  .109974E+03 S-IN2/LBMOLE B2      =  .153454E+01
          MW2     =  .124497E+02 LBM/LBMOLE     M2      =  .488705E+01
          P2      =  .392919E+02 TORR           P20     =  .290075E+03 PSIA
          R2      =  .288884E-04 GM/CM3         R2      =  .170617E-02 GM/CM3
          T2      =  .271528E+03 K              T20     =  .175525E+04 K

POINT 3   SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION
          (COMBUSTOR) TEMPERATURE

          A3      =  .953294E+02 S-IN2/LBMOLE A3A3SE  =  .133315E+02
          A3A3SG  =  .200000E+02                B3      =  .161679E+01
          MW3     =  .400551E+01 LBM/LBMOLE     M3      =  .530231E+01
          NSNOZ3  =  .195544E+04 S/LBMOLE       P3      =  .179710E+02 TORR
          P30     =  .133074E+03 PSIA           RE3     =  .187829E+04
          R3      =  .186036E-04 GM/CM3         R30     =  .736704E-03 GM/CM3
          T3      =  .620454E+02 K              T30     =  .600000E+03 K
          W3W1    =  .490228E+00                X3X1    =  .152370E+01

POINT 4   SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT
          TEMPERATURE

          A4      =  .956835E+02 S-IN2/LBMOLE B4      =  .161322E+01
          MW4     =  .400551E+01 LBM/LBMOLE     M4      =  .530231E+01
          P4      =  .179710E+02 TORR           P40     =  .133074E+03 PSIA
          R4      =  .186036E-04 GM/CM3         R40     =  .736704E-03 GM/CM3
          T4      =  .620454E+02 K              T40     =  .600000E+03 K
          W4W2    =  .490228E+00                X4X2    =  .152370E+01
```

```
POINT 5  CONSTANT-AREA MIXING REGION EXIT

         A5       =  .205658E+03 S-IN2/LBMOLE G5        =  .157943E+01
         MW5      =  .735148E+01 LBM/LBMOLE   M5        =  .486401E+01
         P5       =  .307203E+02 TORR         P50       =  .845920E+04 TORR
         R5       =  .262852E-04 GM/CM3       R50       =  .921547E-03 GM/CM3
         T5       =  .137773E+03 K            T50       =  .108210E+04 K
         W5W2     =  .149023E+01              X5X2      =  .252370E+01

POINT 6  ISENTROPIC EXPANSION REGION EXIT

         A6       =  .406298E+03 S-IN2/LBMOLE G6        =  .157943E+01
         MW6      =  .735148E+01 LBM/LBMOLE   M6        =  .610993E+01
         P6       =  .100928E+02 TORR         P60       =  .845928E+04 TORR
         R6       =  .129910E-04 GM/CM3       R60       =  .921547E-03 GM/CM3
         T6       =  .915840E+02 K            T60       =  .108210E+04 K
         W6W2     =  .149023E+01              X6X2      =  .252370E+01

POINT 7  MIRROR PURGE CONDITIONS

         G7       =  .139962E+01             MW7       =  .280134E+02 LBM/LBMOLE
         T70      =  .300000E+03 K           W7W2      =  .149023E-01
         X7X2     = 0.

POINT 8  LASER CAVITY EXIT

         A8       =  .718915E+03 S-IN2/LBMOLE G8        =  .157692E+01
         MW8      =  .725491E+01 LBM/LBMOLE   M8        =  .228308E+01
         P8       =  .387840E+02 TORR         P80       =  .477047E+03 TORR
         RF8      =  .375835E+05              R8        =  .788141E-05 GM/CM3
         RA8      =  .387049E-04 GM/CM3       T8        =  .573263E+03 K
         TA8      =  .143582E+04 K            W8W2      =  .150513E+01
         X8X2     =  .257931E+01
```

```
                                PRESSURE RECOVERY SECTION

                                      INITIAL DATA:

         A3A2     =  .275000E+01                 A7A6     =  .300000E+01
         EJECT    =   CAE                        ETA12    =  .750000E+00
         G5       =  .129000E+01                 MW5      =  .202040E+02 LBM/LBMOLE
         P50      =  .450000E+03 PSIA            P7       =  .760000E+03 TORR
         T50      =  .281480E+04 K

                                     RESULTANT DATA:

POINT 1  LASER CAVITY EXIT AND NORMAL SHOCK DIFFUSER ENTRANCE

         A1       =  .718915E+03 S-IN2/LBMOLE G1       =  .157692E+01
         MW1      =  .726491E+01 LBM/LBMOLE   M1       =  .228388E+01
         P1       =  .387840E+02 TORR         P10      =  .477047E+03 TORR
         R1       =  .788141E-05 GM/CM3       R10      =  .387049E-04 GM/CM3
         T1       =  .573263E+03 K            T10      =  .143582E+04 K

POINT 2  NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DIFFUSER ENTRANCE

         A2       =  .718915E+03 S-IN2/LBMOLE ETA12    =  .750000E+00
         G2       =  .157692E+01              MW2      =  .726491E+01 LBM/LBMOLE
         M2       =  .561754E+00              P2       =  .179183E+03 TORR
         P20      =  .227361E+03 TORR         R2       =  .158612E-04 GM/CM3
         R20      =  .184468E-04 GM/CM3       T2       =  .131603E+04 K
         T20      =  .143582E+04 K            W2W1     =  .100000E+01
         X2X1     =  .100000E+01

POINT 3  SUBSONIC DIFFUSER EXIT  AND SUDDEN ENLARGEMENT ENTRANCE

         A3       =  .197702E+04 S-IN2/LBMOLE ETA23    =  .969997E+00
         G3       =  .157692E+01              MW3      =  .726491E+01 LBM/LBMOLE
         M3       =  .171354E+00              P3       =  .215514E+03 TORR
         P30      =  .220540E+03 TORR         R3       =  .176336E-04 GM/CM3
         R30      =  .178933E-04 GM/CM3       T3       =  .142376E+04 K
         T30      =  .143582E+04 K            W3W1     =  .100000E+01
         X3X1     =  .100000E+01

POINT 4  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SECONDARY NOZZLE EXIT

         A4       =  .842138E+03 S-IN2/LBMOLE G4       =  .157692E+01
         MW4      =  .726491E+01 LBM/LBMOLE   M4       =  .775000E+00
         P4       =  .142559E+03 TORR         P40      =  .220540E+03 TORR
         R4       =  .135704E-04 GM/CM3       R40      =  .178933E-04 GM/CM3
         T4       =  .122379E+04 K            T40      =  .143582E+04 K
         W4W1     =  .100000E+01              X4X1     =  .100000E+01

POINT 5  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR PRIMARY NOZZLE EXIT

         A5       =  .258989E+03 S-IN2/LBMOLE G5       =  .129000E+01
         MW5      =  .202040E+02 LBM/LBMOLE   M5       =  .383364E+01
         P5       =  .145169E+03 TORR         P50      =  .450000E+03 PSIA
         R5       =  .523150E-04 GM/CM3       R50      =  .267851E-02 GM/CM3
         T5       =  .899001E+03 K            T50      =  .281480E+04 K
         W5W1     =  .272616E+01              X5X1     =  .980266E+00
```

```
POINT 6  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR EXIT AND SUBSONIC
         DIFFUSER ENTRANCE

         A6      =  .110113E+04 S-IN2/LBMOLE G6      =  .136726E+01
         MW6     =  .136700E+02 LBM/LBMOLE   M6      =  .485229E+00
         P6      =  .673719E+03 TORR         P60     =  .790379E+03 TORR
         R6      =  .676222E-04 GM/CM3       R60     =  .758725E-04 GM/CM3
         T6      =  .218390E+04 K            T60     =  .228346E+04 K
         W6W1    =  .372616E+01              X6X1    =  .198027E+01

POINT 7  SUBSONIC DIFFUSER EXIT

         A7      =  .330338E+04 S-IN2/LBMOLE ETA67   =  .975563E+00
         G7      =  .138726E+01              MW7     =  .136700E+02 LBM/LBMOLE
         M7      =  .142690E+00              P7      =  .760000E+03 TORR
         P70     =  .711065E+03 TORR         R7      =  .732439E-04 GM/CM3
         R70     =  .740184E-04 GM/CM3       T7      =  .227450E+04 K
         T70     =  .228346E+04 K            W7W1    =  .372616E+01
         X7X1    =  .198027E+01
```

```
                          SYSTEM CALCULATION SECTION

                                INITIAL DATA:

  EREACT  =   IRFNA/MMH                   NBANK   =             2
  NEJECT  =           1                   RTIME   =  .600000E+02 S
  WPP3    =  .189645E+04 GM/S

                           REACTANT STORAGE METHOD

   REACT       C2H4        HE                          NF3         O2
   PHASE       GAS         GAS                         GAS         GAS
   CONT        SPH         CYL                         SPH         CYL
   STEMP       300.0 K     300.0 K                     300.0 K     300.0 K
   STIME       INFINITE    INFINITE                    INFINITE    INFINITE

   SPRES       4.1E+07 PA 4.1E+07 PA                   1.2E+07 PA 4.1E+07 PA
               (6000 PSI) (6000 PSI)                   (1800 PSI) (6000 PSI)
   RFSYS       BLD         BLD                         BLD         BLD
   MATER       TI          TI                          SS          TI

   REACT       N2-AW       H2O-CS      MMH         IRFNA
   PHASE       GAS         LIQ         LIQ         LIQ
   CONT        SPH         SPH         CYL         SPH
   STEMP       300.0 K     368-388 K   300.0 K     300.0 K
   STIME       INFINITE    INFINITE    INFINITE    INFINITE

   SPRES       4.1E+07 PA 1 ATM        1.25*P0     1.25*P0
               (6000 PSI)
   RFSYS       BLD         RFP         PGS         PGS
   MATER       TI          AL          TI          AL

                               RESULTANT DATA:

                           SYSTEM SCALE-UP FACTOR

  XLP      =  .901567E-03 GMOLE/S

                       LASER DEVICE SYSTEM VOLUME/MASS

  MINJ     =  .111066E+03 LBM
  MCB      =  .188583E+03 LBM
  MBASE    =  .173223E+03 LBM              VCOMB    =  .209325E+01 FT3
  MCAV     =  .511697E+02 LBM              VCAV     =  .194141E+01 FT3
  MAW      =  .636901E+02 LBM              VAW      =  .764622E+00 FT3
  MCS      =  .749931E+03 LBM              VCS      =  .125568E+02 FT3
  MOPY     =  .159779E+04 LBM              VOPY     =  .701353E+02 FT3
  MOS      =  .212183E+03 LBM
  MLRGEG   =  .147504E+03 LBM
  MLLINE   =  .570849E+02 LBM
              -----------                               -----------
  MLDHOW   =  .335223E+04 LBM              VLDHDW   =  .874914E+02 FT3
  MLRT     =  .254120E+05 LBM              VLRT     =  .473961E+03 FT3
              -----------                               -----------
  MLOS     =  .287642E+05 LBM              VLOS     =  .561453E+03 FT3
```

```
                    PRESSURE RECOVERY SYSTEM VOLUME/MASS

MSUPD    =  .552167E+03 LBM          VSUPD    =  .181070E+02 FT3
MSUBD    =  .207613E+03 LBM          VSUBD    =  .825893E+01 FT3
MEJECT   =  .230809E+05 LBM          VEJECT   =  .245474E+04 FT3
MERREG   =  .253855E+03 LBM
MELINE   =  .167518E+02 LBM
            -----------                          -----------
MPRHOW   =  .241112E+05 LBM          VPRHOW   =  .248111E+04 FT3
MERT     =  .875665E+04 LBM          VERT     =  .133359E+03 FT3
            -----------                          -----------
MPRS     =  .328679E+05 LBM          VPRS     =  .261447E+04 FT3

                       SYSTEM VOLUME/MASS SUMMARY

MLDS     =  .287642E+05 LBM          VLDS     =  .561452E+03 FT3
MPRS     =  .328679E+05 LBM          VPRS     =  .261447E+04 FT3
MMISC    =  .800000E+03 LBM
            -----------                          -----------
MTOTAL   =  .624321E+05 LBM          VTOTAL   =  .317592E+04 FT3
                                     VSYSTM   =  .635184E+04 FT3

WBASE    =  .293662E+03 IN           LLDS     =  .747904E+01 IN
LPRS     =  .937150E+03 IN

LBXDEV   =  .944629E+03 IN           WBXDEV   =  .323028E+03 IN
HAXDEV   =  .236738E+03 IN           VBXDEV   =  .418048E+05 FT3
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